**Systems Modeling and Assessment for Policy**
**Spring 2010**
**ESD.936, MW, 1-2:30 (56-154)**
**Instructor: Noelle E. Selin** (selin@mit.edu)
Syllabus as of 28 January 2010

**Course Description (MIT Catalog):**
This course explores how scientific information can be used to inform policy decision-making processes through the use of quantitative modeling techniques. Incorporates both hands-on analysis and practice using models as well as evaluation of the use and effectiveness of models in decision-making. Assesses the full spectrum of model complexity from simple box model calculations to complex, global systems models. Issues addressed include scientific assessment processes; integrated assessment modeling; model frameworks; and scenarios. Examples focus on models and information used for earth system governance, with selected examples from other areas of application.

**Course Synopsis:**
This course is designed to provide students with the critical tools necessary to evaluate the use of models and scientific assessments in decision-making and policy. Students will gain understanding and awareness of how models work, practice using models to conduct policy-relevant analyses, and evaluate the effectiveness of models and scientific assessments in decision-making contexts. This is thus an appropriate course both for students who are planning to develop or build models, as well as those who are potential users of model analyses or output. While many of the examples will be drawn from modeling of earth and environmental systems, the techniques and frameworks applied can be used across multiple issue domains. Guest lecturers throughout the semester will introduce examples from other areas of application. Students are welcome to choose term projects from their own areas of interest.

**Course Outline and Content:**
The course is divided into four sections. The first section introduces the context of the use of scientific assessment and models in policy and decision-making, and presents the various types of models and assessments used in decision-making contexts.

The second section gives an overview of modeling and analytical tools useful in constructing and evaluating models, including assessment frameworks. These include ways to evaluate credibility, salience and legitimacy and the effectiveness of information. Frameworks analyzed include vulnerability, scenario-based approaches and risk assessment.

The third section applies the modeling and analytical tools learned in the previous section to discussion of case studies of models in policy, including cases on acid rain, fisheries, population, climate change, and chemicals.

The fourth and final section will conclude by exploring efforts to model the whole earth system for sustainability decision-making. Students will also present projects applying course techniques to evaluating or conducting model analyses.

**Learning Objectives:**
This course bridges an important gap between courses that focus on quantitative techniques, and those emphasizing policy and decision-making. In contrast to other offerings that focus on either techniques or applications, this course presents an integrated approach to designing policy-relevant models.

By taking this course, students will:

- Gain experience using quantitative modeling techniques, such as box modeling, dispersion modeling, Monte Carlo simulations, statistical modeling, etc.
- Understand model uncertainties, how to quantify them from a modeling perspective, and how to conceptualize and communicate uncertainties in a policy and decision-making context.
- Identify common approaches to modeling from different disciplines, and learn strategies for combining models of social and natural processes.
- Contribute to analyzing and developing "best practices" for the uses of models in policy.

Courses will be conducted with a combination of lectures, discussion and hands-on learning exercises.

**Student Background and Prerequisites:**
This course is appropriate for graduate students (Master's or PhD level) who are interested in the technical and social processes that underlie the design of models for policy-relevant applications. I expect that this course will draw students with varied backgrounds, including both natural and social sciences. For example, such students may include (but are not limited to!) those with ongoing research in areas of modeling (including science, engineering, economics, etc.), those studying the role of scientific information in policy processes, or those with career interests in interpreting scientific results for decision-making.

The common element that all students in this class should have is some experience with quantitative techniques. Quantitative modeling exercises in class and in problem sets will require some knowledge of differential equations. Some experience with using or analyzing the results of quantitative models would also be helpful, but is not required.

**Assignments and Grading:**
*Problem Sets (30% of grade – 10% each)*: Students will complete three problem sets during the course of the semester (#1: *Box Models and Quantitative Techniques, #2:*

*Risk Assessment and Model Communication, #3 Chemical Fate and Transport*). Through these problem sets, students will gain practice applying quantitative modeling techniques to policy-driven questions. Problem sets will consist of both quantitative calculations (some computer-based) and short-answer questions.

*Model Assessment Project (40% of grade)*: A term project will assess a particular model of interest, chosen individually in consultation with the instructor. Students may choose to a) conduct decision-focused analyses using a quantitative modeling approach, or b) evaluate the use of model information in a decision-making or policy process. Students will be asked to present their analyses to the class. The project is described further in the next section, and more information on the project will be provided in class.

*Participation and in-class model exercises (30% of grade)*: This class will emphasize hands-on approaches to models and assessment, and thus class participation will be critical to learning. In-class model exercises will give students the opportunity to develop experience in using and analyzing modeling tools.

**Term Project:**
Individual term projects (Model Assessment Project) are a critical element of the course. Students will choose a particular decision-relevant model or decision-making process in which models were used. Students may choose a model-focused project (in which they will conduct decision-relevant simulations), or a policy-focused project (in which they will analyze the use of quantitative information in a decision-making process). For example, in a model-focused project, a student may choose to identify an area where policies have historically been ineffective, and design and execute a model that could explain the outcome or inform decision-making. In a policy-focused project, a student could analyze a policy process where models were used or misused, and issue recommendations for future quantitative analyses.

Students will present their term projects to the class at the end of the semester, and will be asked to submit a brief write-up of the results (in the form of a focused 3-5 page policy memo) and a detailed PowerPoint presentation.

**Guest Lectures:**
Guest lecturers during the semester will speak about their experience using models in decision-making processes ("war stories"). Guest lectures will present models in areas other than earth and environmental system modeling, and may present alternative quantitative approaches used in their areas.

**Readings:**
There is no required textbook for this class. Readings for each class (listed below) will be provided on the course web site in PDF format.

## Class Schedule

| Date | Class Topic | Assignments |
|---|---|---|
| Wednesday, Feb. 3 | Introduction | |
| Monday, February 8 | From Simple Calculations to Complex Models | |
| Wednesday, February 10 | Policy analysis techniques: What makes scientific information effective in policy? | |
| Tuesday, February 16 | Quantitative techniques: Box models and lifetimes | Problem Set #1 handed out |
| Wednesday, February 17 | Model frameworks: Scenarios | |
| Monday, February 22 | Quantitative techniques: Optimization | |
| Wednesday, February 24 | Model frameworks: Risk assessment | |
| Monday, March 1 | Field Trip: Museum of Science | Problem Set #1 due; Problem Set #2 handed out |
| Wednesday, March 3 | Acid Rain: Air pollution science and models | |
| Monday, March 8 | Acid Rain: Policy outcomes | |
| Wednesday, March 10 | Population and Environmental Impacts | Problem Set #2 due ; |
| Monday, March 15 | Fisheries Management | |
| Wednesday, March 17 | Models and Policy War Stories #1 | Problem Set #3 handed out |
| Monday, March 29 | Vulnerability and the Arctic | |
| Wednesday, March 31 | Chemicals: Screening and Assessment Models | |
| Monday, April 5 | Chemicals: Policy implementation and the Stockholm Convention | |
| Wednesday, April 7 | Models and Policy War Stories #2 | |
| Monday, April 12 | Climate Change: Scientific models | Problem Set #3 due |
| Wednesday, April 14 | Models and Policy War Stories #3 | |
| Wednesday, April 21 | Climate Change: Modeling Applications | |
| Monday, April 26 | Climate Change: Policy Application | |
| Wednesday, April 28 | Earth System Models | |
| Monday, May 3 | Models and Policy War Stories #4 | |
| Wednesday, May 5 | Term Project Presentations | Term Project write-ups due in class |
| Monday, May 10 | Term Project Presentations | |
| Wednesday, May 12 | Wrap-up and ways forward: Models for sustainability? | |

**Course Content and Readings:**

## I. INTRODUCTION

### #1 (Wednesday, February 3): Introduction

### #2 (Monday, February 8): From Simple Calculations to Complex Models
J. Lubchenco. 1998. "Entering the Century of the Environment: A New Social Contract for Science." *Science* 279 (5350), 491.
N. Oreskes, K. Shrader-Frechette, and K. Belitz. 1994. "Verification, Validation, and Confirmation of Numerical Models in the Earth Sciences." *Science* 263 (5147), 641.

## II. FRAMEWORKS AND ANALYSIS TOOLS

### #3 (Wednesday, February 10): Policy analysis techniques: What makes scientific information effective in policy?
A. E. Farrell, J. Jäger, and S. D. VanDeveer. 2006. "Overview: Understanding Design Choices." Chapter 1 in: A. E. Farrell and J. Jäger, eds. *Assessments of Regional and Global Environmental Risks: Designing Processes for the Effective Use of Science in Decision-Making*. Washington, DC: Resources for the Future.

### #4 (Tuesday, February 16): Quantitative techniques: Box models and lifetimes
"Simple Models." Chapter 3 in: D. J. Jacob, *Introduction to Atmospheric Chemistry*. Princeton: Princeton U., 1999. Available online at: http://acmg.seas.harvard.edu/people/faculty/djj/book/index.html

*Problem Set #1 handed out in class Tuesday, February 16*

### #5 (Wednesday, February 17): Model frameworks: Risk assessment
NRC (National Research Council). 1996. Understanding Risk: Informing Decisions in a Democratic Society. Washington, DC: National Academy Press. [Chapter 1]]
P. Slovic. 2003. "Going beyond the Red Book: The sociopolitics of risk." *Human and Ecological Risk Assessment*. 9(5):1181.
Committee on Improving Risk Analysis Approaches Used by the U.S. EPA, National Research Council, 2009. *Science and Decisions: Advancing Risk Assessment.* [Read summary, and skim relevant chapters online at http://www.nap.edu/catalog.php?record_id=12209]

### #6 (Monday, February 22): Quantitative Techniques: Optimization (Guest Lecture, Mort Webster (MIT/ESD))

### #7 (Wednesday, February 24): Model frameworks: Scenarios
B. C. O'Neill and N. Nakicenovic. 2008, "Learning from global emissions scenarios." *Environmental Research Letters* 3, 045014
M. G. Morgan and D. W. Keith. 2008. "Improving the way we think about projecting future energy use and emissions of carbon dioxide." *Climatic Change* 90: 189-215.

Y. Garb, S. Pulver and S. D. VanDeveer. 2008. "Scenarios in society, society in scenarios: Toward a social scientific analysis of storyline-driven environmental modeling." *Environmental Research Letters* 3, 045015

**#8 (Monday, March 1): Museum of Science Field Trip to Making Models exhibit***
**[FYI, class will be slightly longer to allow for transit time]**
*Problem Set #1 Due. Problem Set #2 handed out.*

**III. CASE STUDIES OF MODELS IN POLICY**

**#9 (Wednesday, March 3): Acid Rain: Air pollution science and models**
W. Tuinstra et al. 1999. "Using Computer Models in International Negotiations: The Case of Acidification in Europe." *Environment* 41(9):33-42.
L. Hordijk. 1991. "Use of the RAINS Models in Acid Rain Negotiations in Europe." *Environmental Science and Technology*. 25(4): 596-603.

**#10 (Monday, March 8): Acid Rain: Policy outcomes**
W. Tuinstra et al. 2006. "Moving boundaries in transboundary air pollution co-production of science and policy under the convention on long range transboundary air pollution." *Global Environmental Change* 16(4):349-363.

**#11 (Wednesday, March 10): Population and Environmental Impacts**
A. DeSherbinin et al. 2007. "Population and Environment." *Annual Review of Environment and Resources* 32:345-73.
M. Chertow. 2001. "The IPAT Equation and its Variants: Changing Views of Technology and Environmental Impact." *Journal of Industrial Ecology* 4(4):13-29.
P.E. Waggoner and J. H. Ausubel. 2002. "A framework for sustainability science: A renovated IPAT identity." *PNAS* 99(12):7860-7865.
*Problem Set #2 due.*

**#12 (Monday, March 15): Fisheries Management**
J. Layzer. 2006. "Crisis in the New England Fisheries", Chapter 10 in *The Environmental Case*, Washington, DC: CQ Press.
G. Hardin. 1968. "The Tragedy of the Commons," *Science* 162:1243-1248.
E. Ostrom et al. 1999. "Revisiting the Commons: Local Lessons, Global Challenges," *Science* 284:278-282.

**#13 (Wednesday, March 17): Models, Assessment and Policy "War Stories" #1: Ken Strzepek (U. Colorado) on Communicating Water Models to Policy Makers in Africa**
*Problem set #3 handed out in class.*

**#14 (Monday, March 29): Vulnerability and the Arctic**

B. L. Turner II *et al.* 2003. "A Framework for Vulnerability Analysis in Sustainability Science." *Proceedings of the National Academies of Sciences (PNAS)* 100(14):8074-8079.
Arctic Climate Impact Assessment, "Climate Change in the Context of Multiple Stressors and Resilience," Chapter 17, http://www.acia.uaf.edu/PDFs/ACIA_Science_Chapters_Final/ACIA_Ch17_Final.pdf

**#15 (Wednesday, March 31): Chemicals: Scientific Models (Interactive activity)**
B. D. Rodan et al. 1999. "Screening for Persistent Organic Pollutants: Techniques to Provide a Scientific Basis for POPs Criteria in International Negotiations." *Environmental Science and Technology* 33: 3482-3488.
J. Klasmeier et al. 2006. "Application of Multimedia Models for Screening Assessment of Long-Range Transport Potential and Overall Persistence." *Environmental Science and Technology* 40(1):53-60.

**#16 (Monday, April 5): Chemicals: Policy implementation and the Stockholm Convention**
P. M. Kohler. 2006. "Science, PIC and POPs: Negotiating the Membership of Chemical Review Committees under the Stockholm and Rotterdam Conventions," *Review of European Community & International Environmental Law* 15(3):293-303
H. Selin and N. Eckley. 2003. "Science, Politics and Persistent Organic Pollutants: The Role of Scientific Assessments in International Environmental Cooperation." I*nternational Environmental Agreements: Politics, Law and Economics* 3(1): 17-42

**#17 (Wednesday, April 7): Models, Assessment and Policy "War Stories" #2 (Guest Lecture TBA)**

**#18 (Monday, April 12): Climate Change: Scientific models**
P.N. Edwards. 2001. "Representing the Global Atmosphere: Computer Models, Data and Knowledge about Climate Change." In: C.A. Miller and P. N. Edwards, eds., *Changing the Atmosphere*. Cambridge, MA: MIT Press.
L. J. Donner and W. G. Large. 2008. "Climate Modeling." *Annual Review of Environment and Resources* 33:1-17.
"The Carbon Cycle." Chapter 11 in: M.B. McElroy, "The Atmospheric Environment: Effects of Human Activity," Princeton: Princeton U, 2002.
*Problem Set #3 due.*

**#19 (Wednesday, April 14): Models, Assessment and Policy "War Stories" #3: John Reilly (MIT-Sloan) on Communicating Economic Modeling to Congress**

**#20 (Wednesday, April 21): Climate Change: Interactive activity (Guest Lecture: Travis Franck (Tufts))**
*In-class activity #4: Climate Modeling*
Background handout to be circulated

**#21 (Monday, April 26): Climate Change: Policy Application**
M. Lahsen. 2005. "Seductive Simulations? Uncertainty Distribution Around Climate Models." *Social Studies of Science* 35:895-922.
D. Liverman. 2007. "From Uncertain to Unequivocal: The IPCC Working Group I Report: Climate Change 2007 – The Physical Science Basis." *Environment* 49(8): 28-32

**IV. MODEL EVALUATION AND POLICY PLANNING**

**#22 (Wednesday, April 28): Earth System Models**
F. Biermann. 2007. "'Earth system governance' as a crosscutting theme of global change research." *Global Environmental Change* 17:326-337.
A. Sokolov et al. 2009. "Probabilistic Forecast for Twenty-First-Century Climate Based on Uncertainties in Emissions (Without Policy) and Climate Parameters," *Journal of Climate*, 22(19): 5175-5204.

**#23 (Monday, May 3): Models, Assessment and Policy "War Stories" #4 (Guest Lecture TBA)**

**#24 (Wednesday, May 5): Student presentations of model projects #1**
*Term project write-ups due.*

**#25 (Monday, May 10): Student presentations of model projects #2**

**#26 (Wednesday, May 12): Wrap-up and ways forward: Models for sustainability?**
S. Jasanoff. 2004. "Heaven and Earth: The Politics of Environmental Images," In: S. Jasanoff and M. L. Martello, eds, *Earthly Politics: Local and Global in Environmental Governance,* Cambridge, MA: MIT Press.
Claussen, M. 2002. "Earth system models of intermediate complexity: closing the gap in the spectrum of climate system models." *Climate Dynamics* 18(7):579-586.