

The goal of my project, the Open Model for Environmental Behaviors, is to identify drivers and leverage points in the social system surrounding environmental changes, by developing new approaches in system modeling and analysis. The project combines system dynamics with spatial and network methods, uniquely building on the strengths of each, and synthesizing a wide range of models and data. By identifying underlying forces in coupled social, economic, and political systems, this research can help focus research and facilitate effective policymaking. The spatially explicit and institutionally specific results are accessible to both scientists and the public, helping bridge divisions between these groups. This framework has wide applicability, and a first case study will focus on agricultural behaviors in the tropics.

Anthropomorphic climate change and environmental degradation are among the most pressing and intractable issues of our time. Institutions and individuals may favor changes, but mutually reinforcing incentives make action difficult or costly. Classic systems dynamics pioneered techniques for finding “leverage points” in such systems, places where small changes can make pervasive differences, using computational models. One weakness of system dynamics is that it is hugely aggregative, both demographically and spatially. Ahmad et al. (2004) addresses the spatial aggregation by integrating geographic information system modeling (GIS) and system dynamics, calling the approach spatial system dynamics.

The Open Model extends this approach with (1) support for multiple network maps, (2) overlapping and hierarchical models, (3) integration of time series and spatial data, (4) computational tools for model evaluation, and (5) an open interface for contributions and simulation. Each component builds on a variety of prior work, but their combination is one of this project’s significant contributions. This framework provides the greatest advantage for problems that are currently intractable due to systemic forces, and that are spatially heterogeneous. A wide range of environmental and public health issues fit this description, including emissions from passenger transportation, environmental degradation, obesity, substance abuse, groundwater use, and fishery management, as well as situations fraught with rebound effects and environmental standards that shift activity across borders (e.g., carbon leakage).

Some advantages of each of the core components are summarized below. (1) Networks can represent different ways stocks flow between nodes (e.g. across land or along roads), different demographic groups, and relationships between institutions; and they help capture important features of social systems like the small-world property, scale-free behavior, and hierarchical modularity. (3) Real data integration supports traditional parameter tuning and model verification, but here also drives downscaling simulations, defines the pattern of spatial heterogeneity, and supporting the computational identification of missing or contradictory relationships. (4) With such a high-dimensional model, computational tools are necessary, and one key analytic tool will analyze the system for leverage points by identifying parameter sensitivity, the effects of feedback loops, and the structure of information flows. (5) With an online interface, the project becomes both more manageable and more useful, as a platform for researchers to test their partial models within a larger context.

Many of the core framework elements are already complete and in use for my current research on flooding and self-organized economies. This includes a basic synthesis of system dynamics and network maps, some integration with time series data, and a growing set of tools for analysis. I am also pursuing supporting lines of research, including developing an econometric estimator for fully endogenous systems drawing on signal processing techniques, to be used with model development and parameterization. The complexity of the social, political, and economic system surrounding environmental change requires these kinds of new tools, which have the potential to change how we understand and approach complex problems.