The Limits Of Simplicity: Toward Geocomputational Honesty In Urban Modeling

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Biography

Professor and Chair of the Department of Geography at the University of California, Santa Barbara and Director (Santa Barbara) of the National Center for Geographic Information and Analysis. Author of three books and about 80 articles in GIS, cartography and remote sensing. Former President of the Cartographic and Geographic Information Society. Only person to have given two *Geocomputation* keynote lectures.

Introduction

A model is a an abstraction of an object, system or process that permits knowledge to be gained about reality by conducting experiments on the model. Constraining modeling to that of interest to the geographer, a model should abstract geographic space and the dynamic processes that take place within it, and be able to simulate spatial processes usefully. At the absurd extreme, a model could be more complicated than the data chosen to represent the spatio-temporal dynamics in question. Occam's razor tells us, of course, that when two models are of equal explanatory power, the simpler one is preferred. Einstein stated that "a model should be as simple as possible and yet no simpler." In this paper, I raise the issue of model simplicity, and the question of how much is enough.

The problem of model simplicity is that models have multiple components and are often complicated. Complex systems theory has shown that even simple models can produce complexity and chaos. At the descriptive end, models are sets of inputs, outputs, and algorithms that duplicate processes. Spatial inputs and outputs are usually maps, and the algorithms in geography and Geographic Information Science usually simulate a human or physical phenomenon, changes in the phenomenon, and changes in its cartographic representation. Modeling itself, however, is a process. A modeler builds data or samples that describe the inputs, selects or writes algorithms that simulate the process, applies the model, and interprets the output. Among those outputs are descriptions of model performance, forecasts of unknown outputs, and data sets that may be inputs to further models.

The modeler is also usually responsible for calibrating the model, that is, optimizing performance in some way by tinkering with control parameters and model behavior, and possible validating the model. While validation may actually be impossible in some cases (Oreskes et al, 1994), calibration is obviously among the most essential obligation of modeling. Model calibration is the process by which the controlling parameters of a model are adjusted to optimize the model's performance, that is the degree to which the model's output resembles the reality that the model is designed to simulate. This involves necessarily quantitative assessments of the degree of fit between the modeled world and the real world, and a measurement of the model's resilience, that is how sensitive it is to its input, outputs, algorithms, and calibration. That the obligation to make these assessments is that of the modeler is part of what the authors of the Banff Statement termed "Honesty in modeling" (Clarke et al., 2002). Such an approach could be considered an essential component of modeling ethics generally, and even more so in geography where the real world is out target.

While simplicity in model form is desirable, indeed mandatory, what about simplicity in calibration and sensitivity testing? Reviews of the literature in urban growth modeling for example (e.g. Agarwal et al., 2000; Wegener, 1994; EPA, 2000), show that precious few models are even calibrated at all, let alone validated or sensitivity tested. Most common is to present the results of a model and invite the viewer to note how "similar" it is to the real world. Such a lack of attention to calibration has not, apparently, prevented the models widespead use. Doubts are often assumed away because the data limitations or tractability issues exceed these as modeling concerns.

If one uses the argument that we model not to predict the future, but to change it, then such concerns are perhaps insignificant. Models are also testbeds, experimental environments, or laboratories, where conceptual or philosophical issues can be explored (e.g. McMillan, 1996). This is often the case with games, which with some models are intended for education or creative exploration. Such uses are similar to the link between cartography and visualization; or science and belief. These uses are not, strictly, of concern in science. Science based models have to work in and of themselves. Methods for model calibration include bootstrapping and hind casting. If models are to be used for decisions, to determine human safety in design, or to validate costly programs at public expense, then clearly we need to hold models to a more rigorous, or at least more valid standard. Such issues are of no small importance in geographical models, and in geocomputation at large. Even minor issues, such as random number generation (Van Niel and Leffan, 2003), can have profound consequences for modeling. Whether or not model algorithms and code are transparent is at the very core of science: without repeatability there can be no verification at all.

Method: A Case Study

The simplicity question can, therefore, be restated as: what is the minimum scientifically acceptable level of model calibration? Whether this question can be answered in general for all models is debatable. This paper examines the problem purely for a set of three models as applied to Santa Barbara, California. The three models are the SLEUTH model (Clarke et al., 1997; Clarke and Gaydos, 1998), the WhatIf? Planning model by Richard Klosterman (1900), and the SCOPE model (Onsted, 2002). Of these, only SLEUTH has undergone extensive testing and calibration (Candau, 2000; Silva and Clarke, 2002).

Using the case study approach, the three models are analyzed in terms of their components, their assumptions, and their calibration processes. As a means of further exploring the consequences of modeling variants, their forecasts are also compared and the spatial dissimilarities explored in the light of the data for Santa Barbara. SCOPE, in particular, is a far less spatial model than the other two, and so is harder to compare. Conclusions are drawn about whether the models oversimplify calibration, about the consequences of the oversimplification, and about the geography and methodology of model comparison. The paper concludes with a discussion of model convergence, i.e. whether having models agree with each other is a special form of model cross-validation.

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