MODELING: PROSPECTS AND PROBLEMS

Contemporary geomorphology is increasingly embracing the notion that theoretical concepts from the basic sciences, such as physics and chemistry, provide foundational principles for guiding the development of theories about landscape dynamics. Models, especially mathematical models, provide a structural framework for articulating these theories in a formalized, precise manner. Where the link between landscape processes and the underlying physics or chemistry is strong, we have the classic case of using a model to try to reduce landscape dynamics to underlying physical and chemical mechanisms. In other cases, aggregated variables are employed within more loosely formulated theoretical frameworks in an effort either to predict landform behavior or to determine landscape stability.

Modeling obviously is a specific example of a methodology or technique in geomorphology. Perhaps no other technique has as much mystique or is the center of as much intradisciplinary enthusiasm and skepticism as modeling. Although the mathematical and scientific literacy of geomorphologists has increased enormously over the past 45 years, the discipline still includes a minority that is highly proficient in mathematical modeling, and a majority that either is mathematically illiterate or has only a basic proficiency in mathematics. Geomorphology will benefit greatly from widespread understanding of the strengths and weaknesses of modeling. Such understanding will serve to demystify modeling, allowing its true utility to be objectively evaluated by the community of geomorphologists at large.

Michael Kirkby was invited to provide a context for, and evaluation of, the role of models in geomorphology. In undertaking this task, he emphasizes their importance as thought experiments, the need to maintain simplicity, and the constraint that models can only provide 'possible' explanations. Deborah Lawrence examines the scales at which application of continuum flux models is appropriate and highlights the still underexploited roles of dimensional analysis and scaling in geomorphological modeling. She emphasizes model construction, but also briefly examines some issues related to solution procedures.

Keith Beven uses his extensive experience with hydrological models to explore in detail the notion of models providing 'possible,' rather than 'certain' explanations. He points out that alternative models using a wide variety of parameter sets frequently all produce good fits - a trait that he labels 'model equifinality'. He then suggests ways that this seeming limitation may be exploited.

Sensitivity to initial conditions and unpredictable behavior are patterns in system and model behavior that have long frustrated the generalization that is commonly sought in scientific modeling. Jonathan Phillips discusses the potential role and limitations of nonlinear dynamical systems concepts in explaining such behavioral traits. Of course, the fundamental issue is whether or not such sophisticated descriptions of behavioral patterns can be successfully welded to a body of explanatory theory. Peter Haff provides a detailed consideration of the limitations of models as predictive devices using sediment-transport models as the vehicle for his discussion. He draws particular attention to the difficulties associated with scaling up results and the discovery, and role, of emergent variables as scale is increased.