GEOSCIENCES

Water Ordering Landscapes

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Fractal River Basins. Chance and Self-Organization. IGNACIO RODRIGUEZ-ITURBE and ANDREA RINALDO. Cambridge University Press, New York, 1997. xvi, 547 pp., illus. $100 or £70. ISBN 0-521-47398-5.

I find three principal motivations behind writing a scientific book: to unify questions, solutions, advancements, and discussion on a particular topic; to summarize one's lifetime work; and to have fun. In *Fractal River Basins: Chance and Self-Organization*, theoretical hydrologists Ignacio Rodriguez-Iturbe and Andrea Rinaldo have accomplished all of these.

Both authors have been studying the growth of river basins since before the development of concepts such as fractal geometry, chaos, and self-organized criticality. In this book, they present a detailed and comprehensive application of these concepts to the theoretical hydrology of drainage networks and landscapes.

Looking down from an airplane, the geometry of landscapes and river networks is clearly anything but Euclidean. To those having some experience with fractal geometry, the complexity in the formation of landscapes could obviously be described by fractals and scaling processes. The authors very effectively document the evidence for scaling and multi-scaling (multifractals) in river basins. They leave no doubts that fractal approaches and modeling are the appropriate ways to understand the evolution of river basins.

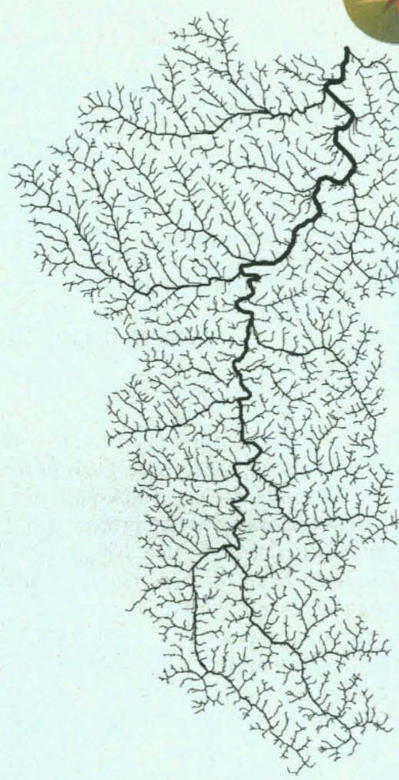
WILLIAM E. DIETRICH

Gentle slopes. A landscape of convex hillslopes, with diffusion-dominated channel initiation.

But why are river basins fractals? This is a very important question that gets at the physics of nature. This book is one of the few that attempt to provide an answer to the question of what will make a natural phenomenon fractal. Nature is never at equilibrium, but in many cases operates in a steady, near equilibrium state in the linear thermodynamic regime. Under such conditions, the most probable events are governed by the theorem of minimum entropy production, and, as such, they are least-dissipation events. Nature, not being able to achieve a state of zero entropy production, settles at the optimal state of least effort. Several studies in the past have shown that the structures corresponding to this state may be fractals. Now the question becomes, what are the dynamics associated with these events that will make their evolution a fractal process? Although this question is still open for debate, meaningful insights can be provided by the theory of self-organized criticality. According to this theory, a system becomes critical when it reaches a steady state at which every part of it becomes unstable. Then a small fluctuation can trigger changes that produce events, which obey power law distributions, at all space and time scales. Note that self-organized criticality should not be confused with self-organization resulting in coherent structures, such as hurricanes. The latter is triggered by the system being far from equilibrium and in the thermodynamic regime where the minimum entropy production theorem does not apply. Self-organized criticality has been used to explain the occurrence and evolution of many fractal phenomena such as earthquakes and sandpiles. Rodriguez-Iturbe and Rinaldo have done an exceptional job relating the fractal nature of river networks and landscapes to the optimality principle and self-organized criticality.

The beauty of this book is that it is basically self-contained. The chapters have a very logical progressive sequence, which allows the reader to follow the ideas clearly. The authors begin by describing the basic characteristics of river basin geomorphology and models for the evolution of drainage networks. They then introduce concepts from fractal geometry and provide experimental evidence for the fractal and multifractal nature of river basins. Subsequent chapters deal with minimum energy and fractal structures, self-organized criticality in fractal river networks, and self-organization in landscapes. The final chapter connects all these topics to runoff processes and geomorphologic theories of the hydrologic response. Previous developments of these theories have been hindered by the absence of a physically based framework for explaining water transport and processes in the atmosphere and land (on or beneath the surface). Such a framework must tie together processes at scales spanning five orders of magnitude in space (100 m to 10,000 km) and many more orders of magnitude in time (from minutes to decades). Increased understanding of nonlinear phenomena and fractal geometries has helped establish this framework, and this book unites them in a remarkable synthesis.

It is not often that we see a subject in applied science being treated so thoroughly and so clearly. Rodriguez-Iturbe and Rinaldo have produced a book that will enlighten and inspire all those interested in theoretical hydrology or the development of landscapes for a long time to come.



IGNACIO RODRIGUEZ-ITURBE

Self-similar streams. The drainage network of the 441 km^2 Raccoon River basin, Pennsylvania, extracted from a digital elevation map with a cell size of 30 m by 30 m.

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