Study finds order in the apparent randomness of Earth's evolving landscape

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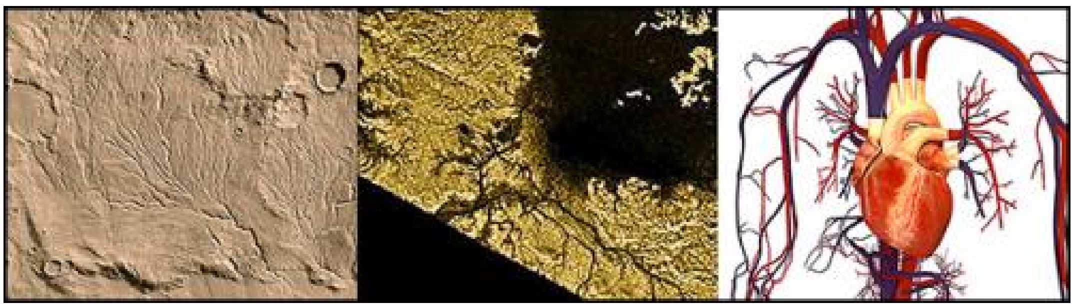

Stanford Earth scientists have created tools to analyze branched networks of Earth-bound channels formed by water and erosion. The work could provide insights into processes that form branched networks like those on the surface of Mars (left) and Titan (center) and in the human circulatory system. Credit: Images courtesy of NASA/JPL and Wikimedia Commons

(Phys.org) —As we all know, water runs downhill, forming channels and branched networks as it flows. It's been that way forever. But, believe it or not, scientists' understanding of these networks hasn't changed much in the last century. Even modern techniques developed and employed since the 1960s cannot easily distinguish between channel networks generated randomly inside a computer and images of channels formed in the real world.

But work by Stanford School of Earth Sciences recent PhD recipient Eitan Shelef and George Hilley, an associate professor of geological and environmental sciences, is beginning to shed light on this fundamental problem, and the tools they created might shine light on not just Earth-bound channels but also those on Mars and even in the human circulatory system.

Shelef's work, recently published in *Geophysical Research Letters*, challenges 50 years of research built on the assumption that the geometry of channel networks reflected a mathematically random process. Shelef and Hilley developed powerful mathematical relationships that captured not just the geometry of hillside channels but the geometry of the underlying landscape as well.

Shelef, now a postdoctoral scholar at Los Alamos National Laboratory, explained that in these equations, the researchers found a simple metric that distinguishes natural channel networks from those formed randomly within a computer, and in doing so, they firmly rejected the mathematically random hypothesis posed in the 1960s.

In rejecting this decades-old hypothesis, Shelef and Hilley can now extract invaluable three-dimensional data from two-dimensional images.

"The way in which branched networks were measured in the past relied only on the two-dimensional map patterns of the channels in the networks," said Hilley, a leading researcher on landscape evolution.

Using high-resolution images captured with laser altimetry, the pair analyzed not only the channels but the ridgelines as well.

By incorporating information about the ridgelines separating the channels, Shelef and Hilley related channel network geometry to the two-dimensional signature left by three-dimensional erosion. Because different erosional processes leave different erosional signatures, which in turn affect channel patterns, Shelef and Hilley's approach allows Earth scientists to infer the processes that erode the landscape simply by analyzing the overlying channel network.

Shelef expanded on this, pointing out that his mathematical tools can help decipher the processes that shape channel networks in areas in which scientists have good imagery but limited elevation data, such as channel networks now buried underground, or channel networks on Mars or Saturn's largest moon, Titan.

For example, images from NASA's Mars Reconnaissance Orbiter showed branched channel networks etched into the red planet's surface. Images beamed back from the Huygens spacecraft as it landed on Titan also showed channels likely formed from flowing liquid methane. Shelef's research could help scientists better understand the processes acting on Titan today and the processes that carved out channel networks on Mars millions, if not billions, of years ago.

"Channel networks are one of the most common and ubiquitous geometric forms found on the surface of this and some other planets," Hilley said.

The pair's analysis of branched networks needn't be limited to flowing liquids. Branched networks appear in life sciences as well, found in tree leaves and even the human circulatory system. With such ubiquity of branched networks, Shelef's Earth science research might reach across disciplines. Understanding the processes that form branched biological networks could provide valuable scientific insights.

By seeing past the randomness inferred from previous research, Shelef and Hilley can better understand the processes that shape the world around us.

More information: 'Symmetry, randomness and process in the structure of branched channel networks,' *Geophysical Research Letters* (DOI: 10.1002/2014GL059816)

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