On the Analysis of Geophysical Networks from Multiscale DEMs

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A lot of information can be extracted from digital elevation models (DEMs) and it offers scientists with invaluable information in terrain characterization. Regions with varied degrees of concavity and convexity represent various degrees of terrain complexities. These complexities explain various physiographic and geomorphic processes. The abstract structures of concave and convex zones represent the valley and ridge connectivity networks respectively. These two unique topological networks have immense use in characterizing the surficial terrain quantitatively via morphometry, hypsometry, allometric scaling and granulometry. The main objective of this paper is to present a method based on morphological transformations in extracting the network and fractal techniques in terrain characterization. We analyze the intereferometrically derived DEM of Cameron Highlands and Tioman region of Malaysia. Cameron Highlands region comprises a series of mountain stations at altitudes between 500 m and 1300 m whereas Tioman region is parts of an Island with altitude ranges from sea level to 500 m.

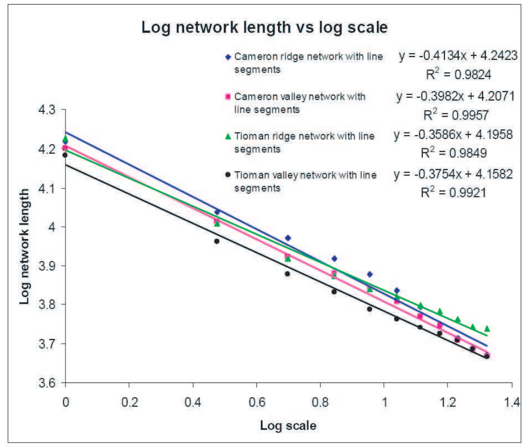

Figure 1.

We employ multiscale nonlinear morphological transformations to generate DEMs at multiple resolutions and to extract channel and ridge networks from these multiscale DEMs. We provide a simple scaling law from the relationship shown by considering the lengths of unique networks derived from multiscale DEMs as functions of radius of the structuring element. It is shown as a simple resolution-independent power-law dimension in the form of $l \sim r^{\alpha}$, where l and r denote length of network at different scale and radius of structuring element respectively. α as the scaling exponent, is the fractal dimension of network. This relationship depict that similar trends have been followed for both ridge and valley connectivity networks and describes the scaling properties of the terrain where the density of the networks decreases as the resolution decreases. The plot of network lengths as functions of radius of structuring element is in logarithm values (figure below). The gradients of best fit lines of these plots indicate that the rate of change in the lengths of the networks, across multiple resolutions. The complexities and intricacies of valley and ridge network change with various types of topography, therefore network length is considered as an important parameter for complex geometry of valley and ridge. We prove that hilly terrain (Cameron Highland region) possesses higher value of exponent as compared to non-hilly terrain (Tioman region). The reason is the rate of change in elevation of hilly terrain across resolution is higher than non-hilly terrain. Relatively, the network intricacies will change more rapidly for hilly terrain. Further analyses of these two networks provide the morphologies of convex ones and hillslopes. The length criterion and fractal dimensions of networks can be used as a powerful criterion for the classification among sub-basins in a large basin. Basins with different topography structure have different network geometry and densities. Emerging river network patterns can be considered to relate with basic underlying physical mechanisms involved in the formation of landscapes of varied complexities. The differences will be reflected by the fractal dimension as this exponent is computed based on network densities across multiple scales.