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Inferring tectonic activity using drainage network and RT model: an example from the western Himalayas, India

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Morphology of the landscape and derived features are regarded to be an important tool for inferring about tectonic activity in an area, since surface exposures of these subsurface processes may not be available or may get eroded away over time. This has led to an extensive research in application of the non-planar morphological attributes like river long profile and hypsometry for tectonic studies, whereas drainage network as a proxy for tectonic activity has not been explored greatly. Though, significant work has been done on drainage network pattern which started in a qualitative manner and over the years, has evolved to incorporate more quantitative aspects, like studying the evolution of a network under the influence of external and internal controls. Random Topology (RT) model is one of these concepts, which elucidates the connection between evolution of a drainage network pattern and the entropy of the drainage system and it states that in absence of any geological controls, a natural population of channel networks will be topologically random. We have used the entropy maximization principle to provide a theoretical structure for the RT model. Furthermore, analysis was carried out on the drainage network structures around Jwalamukhi thrust in the Kangra reentrant in western Himalayas, India, to investigate the tectonic activity in the region. Around one thousand networks were extracted from the foot-wall (fw) and hanging-wall (hw) region of the thrust sheet and later categorized based on their magnitudes. We have adopted the goodness of fit test for comparing the network patterns in fw and hw drainage with those derived using the RT model. The null hypothesis for the test was, the drainage networks in the fw are statistically more similar than those on the hw, to the network patterns derived using the RT model for any given magnitude. The test results are favorable to our null hypothesis for networks with smaller magnitudes (< 9), whereas for larger magnitudes, both hw and fw networks were found to be statistically not similar to the model network patterns. Calculation of pattern frequency for each magnitude and subsequent hypothesis testing were carried out using Matlab (v R2015a). Our results will help to define drainage network pattern as one of the geomorphic proxy to identify tectonically active area. This study also serve as a supplementary proof of the neo-tectonic control on the morphology of landscape and its derivatives around the Jwalamukhi thrust. Additionally, it will help to verify the theory of probabilistic evolution of drainage networks.