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Identifying knickpoints using elevation breaks and offsets in slope-area scaling

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Steepened longitudinal river profile reaches, usually referred as knickpoints, are geomorphological fingerprints of tectonic, climatic and other perturbations, such as stream capture and sea level changes. Morphologically, knickpoints are distinguished as downstream increases in river gradient and as a break in slope-area scaling; that should theoretically correspond to along-stream variations in incision rate. Hence, the presence of knickpoints is a signature of the transgression of the steady state condition of fluvial systems (or of the spatial uniformity of boundary conditions), being thus the main distinctive feature of transient landscapes. Following a rapid change in relative base level fall rates, the fluvial adjustment occurs through an upstream migration of a knickpoint, taken the detachment-limited condition of the river as given. The knickpoint thus define three distinct reaches: the upstream reach not yet affected by the rejuvenation, the over-steepened reach containing the knickpoint, and the downstream reach that is graded to the new base level. Accordingly, migrating knickpoints have been documented in a myriad of geomorphological contexts such as post-glacial rebound, local earthquake faulting, an increase in fault throw rate and change in sea level. The study of the erosional response in upland landscapes to tectonic, climatic and other perturbations is intrinsically tied to the study of knickpoints. However, the ubiquity of knickpoints in landscape evolution studies is not bound with a precise definition of it, or with a unified methodology for its identification. Hence, we address here the issue of the determination of knickpoints in bedrock rivers using quantitative longitudinal profile analysis. We explored the different methods of identification of knickpoints in the literature, focusing on its definition, calculation, theoretical limitations and interpretation possibilities. Additionally, we applied those methods to a mountainous landward passive margin river system, the Quadrilátero Ferrífero – Brazil, that exhibits (i) high relief (max. relief is 1400 m, max. elevation is 2080 m); (ii) presence of knickpoints; (iii) an absence of Quaternary glaciation. Therefore, we seek to test the different methods of identification of knickpoints in a mountainous landscape where we had field constraints of knickpoints. There are two main criteria for the identification of knickpoints: (1) elevation/gradient breaks or; (2) offsets in trends of slope-area scaling. Both of those criteria are somehow subjective as the values for the breaks in (1) as well as the regression limits for the slope-area scaling (2) are arbitrary. We show that the use of those different criteria prescribes different results; the knickpoints identified for both methods are not interchangeable. The method (1) define a higher number of knickpoints than (2) that are more easily identified in the field than the knickpoints that stem from (2). Many times the knickpoints identified from (1) are subsequent, meaning that they are a knickzone rather than a knickpoint. The method (2) is more robust for the characterization of knickzones than (1). We suggest a combined approach for the identification of knickpoints as well as arbitrary values for defining it.