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The role of lavaka in the landscape of Madagascar: A process-based approach

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Lavaka are large teardrop-shaped erosional features sculpting the landscape of Madagascar's highlands. Lavaka have devastating effects, often cutting through entire hillslopes, thereby strongly contributing to the regional sediment yield. Although their genesis is often attributed to human-induced degradation, lavaka are a prime example of an environmental problem whereby the role of human influence is far more complex and ambiguous than a simple one-directional relation between human impact and soil degradation. Notwithstanding recent research efforts to statistically link the spatial distribution of lavaka with land use, the groundwater table, seismicity, precipitation and hillslope gradients, a fundamental, mechanistic understanding of these erosional features remains absent. With this research project we seek to move beyond statistical correlations and identify causal relationships regarding the main driving forces triggering lavaka formation and evolution. This will be coupled to tracing sediment and carbon fluxes through this eroding landscape, from hillslopes to various sediment deposits (floodplains, reservoirs, marches and lake), which is the second research activity of this project. Here, we present our process-based research strategy, developed based upon field data, analogue models and numeric simulations, to test a novel hypothesis where the formation of lavaka is tightly coupled with long-term hillslope evolution processes. Field data on laterite depth variations, groundwater depths and lavaka outlet hydrograph separation will be integrated to derive the relative role of ground- and rainwater in the process of lavaka formation and evolution. These field data will furthermore be used to constrain an analogue model, where lavaka formation and evolution will be simulated. This laboratory set-up will enable us to investigate the role of controlling factors such as ground water table depths, slope gradients and laterite properties. Finally, the identification of the key processes driving lavaka formation through analogue models, will allow the development of a numerical model, capable to simulate the impact of lavaka over different temporal and regional timescales and to eventually implement this in a landscape evolution model. With this presentation we want to introduce our research project, multi-faceted methodology and first results of our field campaigns and analogue modelling experiments.