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# Understanding the Effect of Rainfall and Hydrology in Determining the Efficacy of Fluvial Erosion

**Mario L.V. Martina***

*Department of Hydrology, University School for Advanced Studies, IUSS-Pavia, Italy*

## Editorial

Physically realistic models describing how rainfall drives river erosion are sparse due to difficulties in scaling daily climatic forcing to geological periods. To bridge the gap between short-term hydrology and long-term geomorphology, we developed a theoretical framework for long-term fluvial erosion rates driven by realistic climate by incorporating an established stochastic-mechanistic hydrology model into a threshold-stochastic formulation of stream power. The hydrological theory presents equations for the probability distribution of daily streamflow as a function of climatic boundary conditions. The newly presented criteria are deeply founded in well-established climatic and hydrological theory. This allows us to account for how variations in rainfall intensity, frequency, evapotranspiration rates, and soil moisture dynamics affect river erosion rates in a way that is consistent with existing theories.

Rivers shape the Earth's surface, particularly in high relief, mountain regions; they have been a prominent subject of research in quantitative geomorphology since they represent one of the principal linkages between climate and erosion. In unglaciated mountain ecosystems, mountainous bedrock rivers shape landscape evolution by steepening hillslopes through bedrock incision and carrying the associated debris. They not only establish the relief structure of a mountain, but they also broadcast tectonic signals throughout the terrain. All of this is made possible by the ability of moving water to transfer silt. As the primary source of water, it is obvious to conclude that climate, or more particularly, rainfall, plays an essential effect in landscape change. This was pointed out by Gilbert more than 140 years ago. In the intervening time, a plethora of theoretical models have proposed, and in some cases demonstrated, that climate should play an important role in defining the shape and rate of change of the Earth's surface. Some regard climate in the context of a landscape dominated by fluvial erosion, while others regard it in a broader sense.

Despite theoretical expectations and the observable impact of rainfall on erosion processes at the local level, many studies that seek to relate mean rainfall rates or stream power to erosion rates fail to find a functional link across a wide variety of geographical and temporal dimensions. A few studies, however, reveal a clearer association between rainfall and erosion rates when they carefully analyse elements that may obfuscate the relationship. This implies that a relationship between climate and erosion can emerge when the key confounding factors are tightly controlled. Some of these factors in a fluvially dominated landscape include spatially varying rock type and uplift rate, erosion thresholds, the intensity and frequency of significant storms, the type and amount of vegetation, sediment supply and transport dynamics, channel form, and likely other factors that have yet to be identified. These confounding elements must be understood and accounted for in order to develop a landscape evolution model that integrates genuine climatic forcing, and their potential effect on erosional efficiency must be assessed.

The wide discrepancy in timescales makes comprehending the effects of climate on river erosion difficult. Rainfall rates important to erosion processes and streamflow creation vary over durations ranging from hours to days, but timeframes important to landscape evolution rates range from centuries to millennia. Ecological and hydrological responses to climatic forcing are similarly time-dependent, complicated, and have a significant impact on landscape change. It is difficult to create geomorphic transport equations that quantifiably reflect the net impacts of this complexity throughout the relevant ranges of geographical and temporal scales. Earlier approaches relied on a parameterized effective streamflow, which was thought to capture the average effect of sediment-laden water moving over bedrock.

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***Address for Correspondence:** Mario L.V. Martina, Associate Professor, Department of Hydrology, University School for Advanced Studies, IUSS-Pavia, Italy. E-mail: mario.martina@iusspavia.it*

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