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Bedrock channel sinuosity and discharge variability

J. R. Barbour and C. P. Stark
Lamont-Doherty Earth Observatory, Columbia University

Because climate is a primary control on mountain landscape evolution, climatic boundary conditions should be measurable in topographic relief. However, the quantitative properties of terrain examined so far have been undiagnostic of such boundary conditions, with the possible exception of tectonic uplift rates estimated from slope-area studies. We will present the first unambiguous measurement of a climatic boundary condition acting on a landscape derived purely from its digital elevation model (DEM). Our analysis of shuttle radar elevation data for mountain catchments across the western North Pacific reveals a linear correlation between subcatchment-averaged dem-derived channel sinuosity, the frequency of extreme storms, and the variability of discharge and rainfall. In contrast, mean measures of rainfall and discharge do not correlate with sinuosity. We explain these observations with the aid of a 1d morphodynamic model of flow through a trapezoidal channel which uses a non-linear threshold shear stress law for bedrock erosion and realistic probability distributions of discharge. The model suggests that greater discharge variability, which can result from more frequent floods, drives faster bank versus bed erosion, induces more channel mobility, and by extension produces greater channel sinuosity, and the sensitivity of model sinuosity to discharge variation is a strong function of critical bed shear stress and bedrock erodibility. If this model inference is correct, it indicates that the observed correlation between extreme storm frequency and channel sinuosity is causal, and the current pattern of typhoon strikes and extreme discharge events in the western North Pacific must have persisted long enough for the evolution of bedrock channel sinuosity to record it. In rapidly evolving mountain ranges, erosion rates are modulated by river channel steepness, which adjusts through the evolution of sinuosity. Therefore, our results indicate that mountain river sinuosity contains a great deal of information about the mechanics of bedrock channel erosion, bedrock erodibility, and the role of climate in landscape dynamics.