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Identifying causal links between tectono-geomorphic processes and biodiversity with a coupled landscape-biodiversity evolution model

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Landscapes and their associated ecosystems coevolve over geologic time. Correlative approaches have elucidated the importance of topographic diversity and tectonic history but have not identified specific causal links between tectono-geomorphic processes and biodiversity metrics. To address this issue, we coupled the numerical landscape evolution model DAC (Divide and Capture) with a mechanistic model for biodiversity that simulates dispersal, allopatric speciation, and extinction to develop hypothetical biological signatures of different functional groups to a variety of landscape histories. In our coupled model, DAC-BIO, suitable habitat for terrestrial species is defined using a combination of elevation, slope, and aspect, which are measured at sub-grid scale from the simulated landscape and meant to represent more complex physical parameters such as temperature, precipitation, soil properties, and hydrologic environment. In addition to habitability requirements, species are assigned dispersal characteristics (rate and ability to cross uninhabitable terrain) and speciation rate (isolation time needed to form new species). We test whether distinct trends in the size and number of contiguous habitat patches emerge in response to various tectono-geomorphic processes, including a step change in uplift rate, a shift from uniform uplift to an uplift gradient, steady shortening (horizontal advection), and escarpment retreat. We find that these tectono-geomorphic processes do yield distinct trends in the size and number of habitat patches and that the resulting changes in habitat connectivity across the landscape leaves distinct biological signatures in diversification rates, species richness, and endemic richness.