Linking topography, erosion, and chemical weathering in Earth's most tectonically-active mountains

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Knowledge of hillslope denudation rates and processes is necessary for understanding landscape response to tectonic and climatic forcing and for determining the degree to which mountains regulate biogeochemical cycles and global climate. Landslide erosion and soil production are the principle denudation processes in high-relief terrain, but quantitative estimates of landslide erosion on spatial and temporal scales relevant to landscape evolution are lacking, and there have been no prior measurements of soil production and weathering rates in Earth's most tectonically-active landscapes. I will present landslide erosion rate estimates from the Tsangpo Gorge region of the eastern Himalaya, soil production and chemical weathering rate measurements from the western Southern Alps of New Zealand, and a model of global-scale denudation. Results from the Tsangpo Gorge indicate landslide erosion is coupled with bedrock river incision and rock uplift, but not topography, hence providing the first direct confirmation of a `threshold hillslope' model of landscape evolution that has emerged over the last two decades. Results from the study in New Zealand indicate that soil production rates in the western Southern are rapid, and moreover, soil physical erosion rates are linearly coupled with chemical weathering rates. Using the relationship between physical and chemical denudation rates to model global weathering fluxes as a function of mean local slope, I demonstrate that the small, mountainous fraction of Earth's surface dominates the global chemical weathering flux. The weathering measurements and model results do not support the contention that erosion and weathering are decoupled in rapidly eroding mountains, but instead indicate the presence of strong links among topography, erosion, weathering, and carbon dioxide cycling.