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Numerical simulation of landform evolution for asymmetric mountain ranges: Application to Taiwan

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It has been considered that erosion rates are proportional to the elevation in the first-order approximation except high plateaus such as Tibet. However, there are many mountain ranges with asymmetric features, for example, in Taiwan the eastern slope is much steeper than the western slope. In such asymmetric mountain ranges, we can never consider the erosion rates to be simply proportional to the elevation, because the erosion rate is directly not proportional to the elevation but to the gradient. On this basic concept, we developed a numerical simulation code to investigate the topographic evolution with the stream erosion model by Howard and Kerby (1983), where we gave the asymmetric uplift rates and calculated the erosion rate, proportional to the exponential of the gradient and the drainage area. The topography evolves with time toward a dynamic stable state where uplift balances with erosion. Through the numerical simulations, we found that 1) the mountain ridge does not coincides with the uplift axis, that is, the location of the uplift axis must be farther from the center of the mountain range than that of the mountain ridge, 2) the uplift rate strongly affects the height of the mountain ridge, but not its location nor the time to steady states, 3) the time to the steady state is longer for the case with farther uplift axes from the center of the mountain range, and 4) the mountain axis is nearer the uplift axis in the younger stage of the mountain, but gradually migrates toward the center of the mountain range. Taking these simulation results into account, we applied the stream erosion model to Taiwan for the last 5 Myr. The result of the numerical simulation well explains the gross feature of the present topography in Taiwan, for example the mountain axis of the Central Range locates 10 km west of the Longitudinal Valley in the southern region, while 25 km west in the central region.