Geophysical Research Abstracts
Vol. 20, EGU2018-11829, 2018
EGU General Assembly 2018

On Nonlinearity of Specific Sediment Yield Scaling with Drainage Area

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The specific sediment yield (SSY) is defined as the sediment yield per unit area, and is used for quantifying terrestrial sediment load from a catchment. The inherent hypothesis is that the sediment yield scales with drainage area within homogeneous land surface regions and therefore the SSY is constant across spatial scales. However, frequently observed nonlinear relationships between the SSY and the drainage area suggest the breakdown of this hypothesis (Church and Slaymaker, 1989; Church, 2017). This study analyzes the nonlinearity of the SSY relation through partitioning the sediment source area into channels and their contributing slopes. We hypothesize that the SSY associated with slopes is spatially homogeneous while the sediment load yielded from channels results in the nonlinearity. We tested the hypothesis using the Digital Yellow-River Model (DYRIM), a physically based distributed model of watershed sediment dynamics for the Loess Plateau (Wang et al., 2015). The annual sediment yield from the Huangfuchuan Basin and the Chabagou Basin, with a drainage area at the order of 3000 km2 and 200 km2 respectively, was simulated and analyzed. The simulation results confirm that erosion and deposition within the drainage channel system is the primary reason responsible for the nonlinearity of the SSY. The nonlinear relationship between the flow and sediment discharges as well as the thresholds of sediment supply and carrying capacity are the hydrodynamic mechanisms. The results contribute to provide a physical interpretation of the nonlinear nature of SSY and highlight the channel processes which must be evaluated to estimate sediment yield.