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From soil erosion to sediment load: Modelling land surface sediment transport using global high-resolution datasets for river routing applications

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Knowledge about the production and movement of sediment on the land surface before it ultimately reaches the river system is fundamental to better quantify sediment load in rivers and understand sediment dynamics, which are of critical importance for a wide variety of Earth system processes and global biogeochemical cycles. At large scales with limited data availability, potential soil erosion rate estimates are often based on simplistic models such as the revised universal soil loss equation (RUSLE). The RUSLE approach is able to predict the amount of soil being eroded by water at the pixel scale, and recent efforts have produced results at high spatial resolution globally (Borrelli et al., Nature Communications 8, 2017). However, estimating the flow and sediment connectivity between pixels and the amount of sediment actually reaching the river system remains a challenge. Process-based approaches, such as models based on the Rouse number, the sediment delivery ratio, or the sediment transport capacity, suffer from high data uncertainties when applied at large scales.

Here, we build upon the global soil erosion estimates by Borrelli et al. and develop a large-scale, spatially-explicit overland sediment routing approach that models the movement of displaced soil across the land surface, accounting for deposition in sink areas and ultimately producing net sediment supply estimates. We use a statistically-based approach informed by a novel set of >100 hydro-environmental landscape variables derived from existing global datasets. We use select sediment gauging stations for a set of spatially-diverse headwaters over the continent of Africa for calibration and validation purposes. The results from our overland sediment connectivity model are intended to help identify areas of high sediment deposition rates in the landscape, and the net sediment output estimates could serve as readily available input for sediment load calculations of subsequent river routing models.