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Effects of seasonal variations in vegetation cover and precipitation rates on catchment-scale erosion rates

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Precipitation in wet seasons is the main driver of fluvial erosion and accounts for a significant contribution to annual erosion rates. However, wet seasons also encounter an increase in vegetation cover, which helps to resist erosion. This study quantifies the implications of present-day seasonal variations in rainfall and spatially variable vegetation cover on erosion rates over distinct climate-vegetation settings. We do this using the Landlab-SPACE landscape evolution model modified to account for weathering, rainfall-infiltration-runoff, and the effects of vegetation cover on hillslope and fluvial processes. The input parameters also include present-day SRTM DEM (90m) for the initial condition, MODIS NDVI, and weather station observations of precipitation (between 2000 – 2019). The soil properties (input parameters) and dynamically evolving soil depths were considered to estimate soil-water infiltration using the Green-Ampt method. Simulations were tuned to four selected catchments in the Chilean Coastal Cordillera (~26 °S – ~38 °S) which contains a steep climate (from arid to temperate humid) and ecological gradient with similar granodiorite lithology and tectonic forcings. The size (and mean slopes) of the catchments range from 64 (8°) – 142.5 km^2 (23°). These catchments are not in steady-state with a background uplift rate of 0.05 mm yr^{-1}. We designed multiple sets of simulations to explore the sensitivity of catchment scale erosion rates to seasonal variations in precipitation and/or vegetation cover. The simulations were conducted for 1,000 years (20 years of vegetation and precipitation observations repeated 50 times) with a time-step of 1 season (3 months). After detrending the results for long-term transient changes, the last 20 years were analyzed. Results indicate that when vegetation cover is varied but precipitation is held constant then the amplitude of change in erosion rates is very low (e.g. 17% in the humid setting). Whereas, in simulations with variable precipitation change and constant vegetation cover, and coupled variations in both precipitation and vegetation cover, the amplitude of change in erosion rates is higher and in a similar range (e.g., 95% in the humid setting). The results during wet seasons also indicate that erosion in the semi-arid region is ~2 times and ~4 times more sensitive than mediterranean and humid regions respectively. However, minimal erosion is observed in the arid setting, due to low precipitation subjected to soil infiltration which leads to lower runoff than the erosion threshold. Overall, we found that at a seasonal scale, erosion rates are significantly influenced by precipitation variations and base vegetation cover (moderately by seasonal variations). Secondly, the vulnerability of erosion rates to weather seasonality increases from humid to semi-arid regions.