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Observations and Modelling Results Help to Understand Global Hillslope Asymmetry

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Aspect-controlled vegetation over opposing hillslopes are driven by non-uniform distribution of incoming solar radiation in semi-arid ecosystems. This leads to variation in soil and vegetation characteristics. In mid- to high-latitudes where available soil moisture is a limiting factor for vegetation growth, poleward-facing slopes develop denser vegetation cover providing greater erosion protection than the equatorward-facing hillslopes. The variation in erosion rates across opposing hillslopes leads to the development of topographic asymmetry of hillslopes over long timescales. This asymmetry is quantified by the hillslope asymmetry index (HAI), a metric given as the ratio of the median slope angles of opposite hillslopes. We present a combined approach of modelling and observed data analysis to investigate the relationships of HAI with climatological, geomorphic, and ecologic variables at a global scale. We analysed these relationships using digital elevation topographic data to compute observed HAI for 80 different catchments across the world, where aspect-controlled vegetation has been reported in the literature. Further, we used the CHILD landscape evolution model (LEM), which uses the continuity equation for water, sediment, and biomass, to investigate the control of climatological, geomorphic, and ecologic variables on the development of hillslope asymmetry through a modelling approach,. The outcomes of the study highlights that latitude and mean topographic gradient are the two dominant factors affecting hillslope asymmetry due to their vital role in controlling vegetation density through the modulation of incoming solar radiation. These results improve our understanding on how different climatic variables and geographic properties affect the magnitude of hillslope asymmetry and their implications on landform evolution modelling.