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Wave power and seacliff retreat rates in the Hawaiian Islands

Kimberly Huppert (1), Andrew Ashton (2), and Taylor Perron (3)

(1) GFZ Potsdam, Potsdam, Germany (khuppert@gfz-potsdam.de), (2) Woods Hole Oceanographic Institution, Woods Hole, USA (aashton@whoi.edu), (3) Massachusetts Institute of Technology, Cambridge, USA (perron@mit.edu)

Volcanic ocean islands offer a unique opportunity to quantify the influence of wave power on seacliff retreat rates because they typically have homogeneous bedrock, well-constrained initial topography, and dramatic gradients in wave power where their curving shorelines face different wave regimes. Here, we examine the influence of wave power on 10^4- to 10^6-year sea cliff retreat rates in the Hawaiian Islands. We model the transient evolution of 13 bedrock coastal profiles on the Big Island of Hawai'i, Maui, and Kaho'olawe over their 12 kyr to 1.4 Myr histories, assuming a constant cliff retreat rate and removal of all rock undercut by cliff incision. Since relative sea level change influences the amount of time that coastal erosion occurs at the primary cliff face over these long time periods, we use geophysical modeling and oxygen isotope records to estimate possible sea level histories at each site. We then test a range of cliff retreat rates and relative sea level histories simultaneously to find the best-fit cliff retreat rate at each site and the best-fit relative sea level history to all sites. We find a best-fit relative sea level history consistent with an effective elastic thickness of the lithosphere of 30 km, similar to previous estimates, and relatively steady deflection due to loading over the growth period of a Hawaiian volcano. Cliff retreat rates estimated from our long-term modeling of coastal profile development under changing sea level are systematically higher than rates estimated directly from the width of wave-cut platforms. Using 30-year hindcast wave data, we find positive linear relationships between the best-fit seacliff retreat rates and both mean annual wave power and one-year recurrence interval wave power at each site. These comparisons offer field evidence for a scaling between cliff retreat rates and wave power, providing an empirical basis for modeling bedrock coastal erosion over geologic timescales.