Geophysical Research Abstracts
Vol. 18, EGU2016-5330, 2016
EGU General Assembly 2016

Climatic controls on the pace of glacier erosion

Michele Koppes (1), Bernard Hallet (2), Eric Rignot (3), Jeremie Mouginot (3), Julia Wellner (4), and Katherine Love (2)

(1) University of British Columbia, Dept. of Geography, Vancouver, B.C., Canada (koppes@geog.ubc.ca), (2) University of Washington, Dept. Earth and Space Sciences, Seattle, WA, USA, (3) University of California at Irvine, Dept. Earth System Science, Irvine, CA, USA, (4) University of Houston, Geology, Houston, TX, USA

Mountain ranges worldwide have undergone large-scale modification due the erosive action of ice, yet the mechanisms that control the timing of this modification and the rate by which ice erodes remain poorly understood. Available data report a wide range of erosion rates from individual ice masses over varying timescales, suggesting that modern erosion rates exceed orogenic rates by 2-3 orders of magnitude. These modern rates are presumed to be due to dynamic acceleration of the ice masses during deglaciation and retreat.

Recent numerical models have focused on replicating the processes that produce the geomorphic signatures of glacial landscapes. Central to these models is a simple quantitative index that relates erosion rate to ice dynamics and to climate. To provide such an index, we examined explicitly the factors controlling modern glacier erosion rates across climatic regimes. Holding tectonic history, bedrock lithology and glacier hypsometries relatively constant across a latitudinal transect from Patagonia to the Antarctic Peninsula, we find that modern, basin-averaged erosion rates vary by three orders of magnitude, from 1->10 mm yr-1 for temperate tidewater glaciers to 0.01-<0.1 mm yr-1 for polar outlet glaciers, largely as a function of temperature and basal thermal regime. Erosion rates also increase non-linearly with both the sliding speed and the ice flux through the ELA, in accord with theory. The general relationship between ice dynamics and erosion suggests that the erosion rate scales non-linearly with basal sliding speed, with an exponent n $\approx$ 2-2.62.

Notably, erosion rates decrease by over two orders of magnitude between temperate and polar glaciers with similar ice discharge rates. The difference in erosion rates between temperate and colder glaciers of similar shape and size is primarily related to the abundance of meltwater accessing the bed. Since all glaciers worldwide have experienced colder than current climatic conditions, the 100-fold decrease in long-term relative to modern erosion rates may in part reflect the temporal averaging of warm and cold-based conditions over the lifecycle of these glaciers. Higher temperatures and precipitation rates at the end of glaciations favor the production of water from rainfall, surface melting and internal melting, which promotes sliding, erosion and sediment production and evacuation from under the ice. Hence, climatic variation, more than the extent of ice cover or ice volume, controls the pace at which glaciers shape mountains.