Exploring the controls on permafrost coastal bluff retreat rate, North Slope, Alaska

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ABSTRACT

The Arctic is a region where modern surface warming has had significant effects on geomorphologic processes. Along the Beaufort Sea coastline bounding Alaska’s North Slope, the mean annual coastal erosion rate has doubled from ~7 m yr⁻¹ for 1955-1979 to ~14 m yr⁻¹ for 2002-2007 (Mars and Houseknecht, 2007). Locally, the erosion rate can reach 30 m yr⁻¹, with short term rates that are far greater than this. A robust understanding of the processes that control the rate of coastal erosion is required to predict response to a rapidly changing climate, with implications for sediment and carbon fluxes, oil infrastructure, and animal habitat.

We model the evolution of the permafrost bluffs on the North Slope, constrained by time-lapse imagery, and by measurements of both the oceanic and atmospheric setting. During the sea-ice-free season, relatively warm waters melt a notch into the ice shelf that comprises the bluffs. The cliffs ultimately fail by toppling of polygonal blocks bounded by mechanically weak wedges. The toppled blocks then temporarily armor the coast against further attack. The annual retreat rate is controlled by the length of the sea-ice-free season, water and air temperatures, and the wave history. Our model is forced by air temperature, water temperature, water level, and wave period, and is validated using field and remote sensing observations over a variety of timescales. The model is then used to explore the expected changes in coastal retreat rates for various climate change forcing parameters, including increases in the duration of sea-ice-free conditions, warming ocean temperatures, and changes in storm frequency.

REFERENCES


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