Comparing coastal dynamics between two geomorphologically distinct permafrost affected coastlines in NW Alaska

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Arctic clastic coastlines are some of the most dynamic in the world and have a large impact on cultural and natural resources. Sea ice plays an important role in the erosion and accretion dynamics of these coastlines, and sea ice cover is currently declining at >10% per decade. As a result of declining sea ice cover and an increase in the duration of open water days in the Arctic Ocean, we need to know more about coastal processes in polar seas, specifically how sea ice decline changes coastal processes, the rate at which such coastal changes can occur, and how the effects of declining sea ice interacts with local coastline characteristics including wave fetch, bathymetry, permafrost properties onshore, and pre-existing coastal geomorphology.

To assess the influence of sea ice decline on permafrost coastal dynamics we selected two segments of the coastline in NW Alaska with contrasting geography, surficial geology and geomorphology. Study site A, Cape Krusenstern National Monument (CAKR), has a wave-dominated, west- to south-west facing, coarse-clastic shoreline. Accreted beach ridges, barrier-closed lagoons, permafrost bluffs, longshore gravel bars, and gravelly beaches characterize coastal geomorphology. Study site B, the Bering Land Bridge National Park and Preserve (BELA), has a north-facing coastline with a shoreline characterized by yedoma and thermokarst basin permafrost bluffs, aggrading spits, sandy barrier islands, and open lagoons.

To establish rates of coastal change and identify key geomorphological processes, we digitally mapped the shoreline of both study areas using aerial photographs (1-meter resolution or better) and sub-meter resolution World View-2 satellite imagery from 2003 and 2014, respectively. We compared our data to the results of previous studies based on imagery taken between 1950 and 2003 (Lestak et al., 2010). To better understand the relationship between geomorphology and rates of change, we established geomorphological landform classes for both study areas. We mapped coastal changes within a subset of each study area, using sub meter resolution imagery, over annual time steps to help us better quantify variations in the rate of event driven coastline change.

Mapping results for the period 2003 to 2014 suggest a change in erosion rates within both study sites. Erosion rates for the period 1950 to 2003 in BELA and CAKR were -0.12 m/yr and -0.98 m/yr respectively, where the negative signs indicate shoreline retreat (Gorokhovich and Leiserowiz, 2012). These rates, for the period between 2003 and 2014, increased in CAKR to -0.86 and decreased in BELA to -0.69 m/yr. Rates of erosion were found to vary according to geomorphology, with overwash fans in BELA exhibiting the highest rates of change at -1.3 m/yr. Significant changes in geomorphology were observed for this time period including the development of a 200-meter long spit in CAKR, degradation of ice wedges on upland yedoma bluffs in BELA, and the infilling of numerous barrier island ponds due to overwash events in BELA. Our results illustrate the complexity of coastal responses along Arctic coastlines even within close proximity. To ensure robust projections of future coastal change, further mapping and analysis at intra-annual and sub-meter spatial resolution is necessary to firmly tie together cause and effect of arctic coastal processes with a changing climate.

References

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