# Synopsis of studies at the USGS Pacific Coastal & Marine Science Center (PCMSC) that may be of relevance to sewage lagoon stability and quality in rural Alaska.

**Project website:** http://walrus.wr.usgs.gov/climate-change/hiLat.html
This site is in its infancy but will be populated within the coming months. It contains links to downloadable reports and oblique photography of the North Slope.

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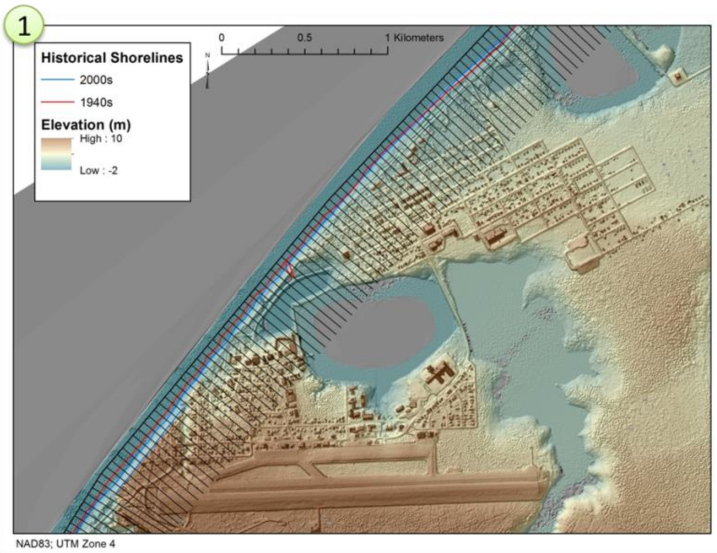
## I. Overview

Our work is primarily focused on evaluating flooding hazards, quantifying shoreline change rates, and understanding the state and movement of subsurface water. We've based our flooding hazard evaluations on numerical models that use atmospheric forcing for both the recent past (1980s to the present) and projected future climate (to the year 2100). The shoreline change work is based on historical data (1940s-200s). And now with our work towards better understanding subsurface flows and overall subsurface geology combined with model outputs and historic rates of change, we are working towards assessing coastal hazards and future land changes. All these processes and hazards (flooding potential, shoreline erosion, land-surface deflation, and sub-surface water transport) have physical linkages to water supply and sanitation, and thus some of our studies might be of relevance to coastal lagoon stability and quality in rural Alaska. Please keep in mind that our work is primarily focused on the Arctic coastal region along Alaska's North Slope.

In the following sections we provide very brief overviews of the types of data and information that we are gathering / generating.

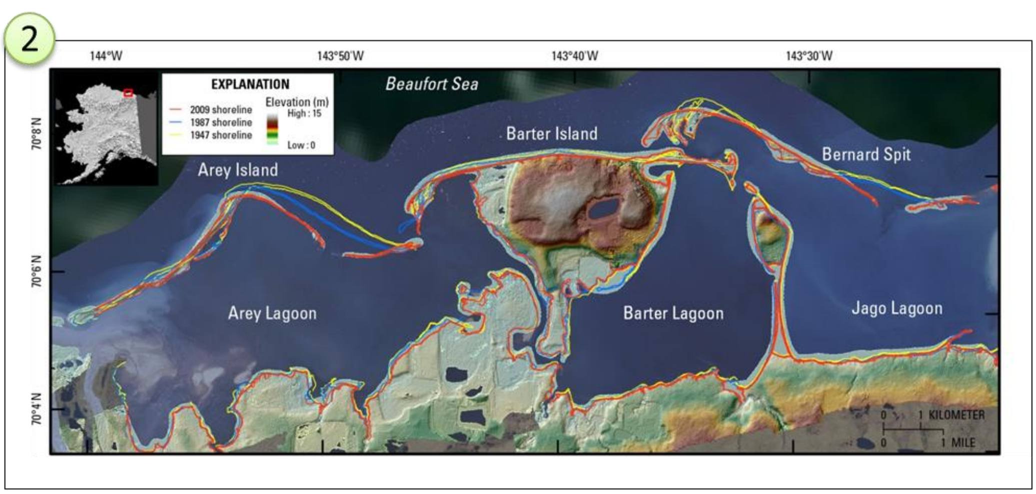
# II. Shoreline change

As part of a U.S. Geological Survey assessment of coastal change hazards, over 11,000 $km^2$ of airborne lidar elevation data were collected along the Arctic coast of Alaska between 2009 and 2012. Data coverage includes the barrier islands and mainland coast between Icy Cape and the U.S.–Canadian border, from the shoreline to ~1.5 km inland. Data coverage extends further inland to around 3 km on the Barrow Peninsula and along the coast of the Teshekpuk Lake Special Area (TLSA). This is one of the first comprehensive lidar datasets collected in a continuous permafrost environment. Many periglacial landscape features, such as patterned ground, ice-wedge polygons, and thermokarst lakes and former lake basins (recent and relict) are discernible in the dataset. Traditional coastal landscape features including shoreline position, beach width, slope, and bluff height and morphology are also distinct. An example is shown in Figure 1.




Example of airborne lidar overlain with historical shorelines and cross-shore transects where shoreline change rates were calculated. Image shows the City of Barrow, Alaska.

Employing the lidar data complemented with older sources, shoreline change rates were calculated for the entire North Slope. A variety of data sources were used to identify past shoreline positions so that the analyses can extend as far back in time as the historical record allows (mid 1940s). Shoreline change rates were calculated every 50 meters along both the open-ocean/barrier coast and the lagoon coast along the entire North Slope. An example is provided in Figure 2.




Example of historical shoreline positions near Barter Island.

# III. Flooding hazards and coastal processes

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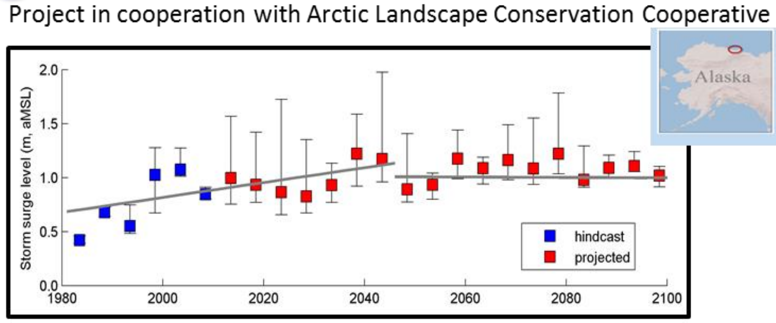
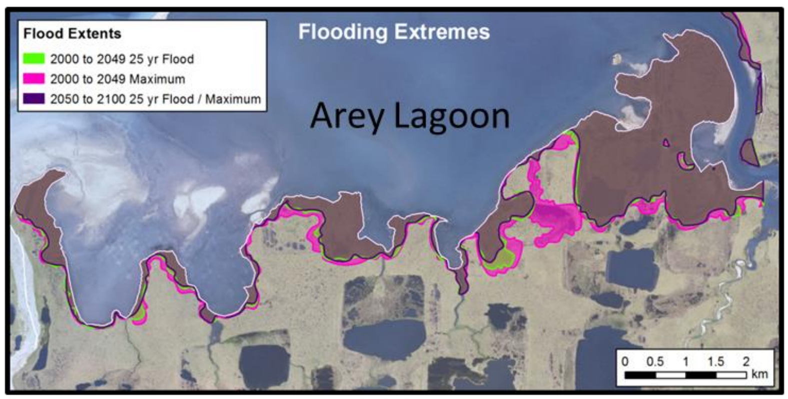
Project in cooperation with Arctic Landscape Conservation Cooperative




Time-series plot of the highest storm surge levels (including an assumed sea level rate of 3.5mm/yr) simulated with a numerical model for the years 1981 through 2100.




Extents of saltwater flooding as derived by allowing the maximum and 25-year return period storm surge levels to flood a high resolution digital elevation model.

Measurements of water levels at the coast are the best way to know how high storm surge levels been. Unfortunately there are very few actual measurements along Alaska's Arctic coast (only one continuously recording tide gauge is available at Prudhoe Bay since 1996 (NOAA)). In lieu of measurements, and with the aim of estimating future storm surge levels in response to changing atmospheric conditions expected with climate change, we used a state-of-the-art numerical model (Deltares Delft3D) to simulate storms and responding water levels in response to passing storms. Wind and atmospheric pressure fields derived from re-analysis products and a suite of Global Climate Models (GCM) were used to hind-cast and make estimates of future storm surge levels in response to climate change. Model results suggest that storm surge levels will increase in the Arctic, and for the RCP 4.5 'stabilizing' scenario (see Figure 3). Peak surges are expected to occur sometime during the mid-part of the 21$^{st}$ century. In northeast Alaska for example, the 25-year and maximum events for the first half of the century are 1.70 m and 1.95 m above approximately mean sea level (aMSL), respectively. Because of the generally low relief this translates to > 6 km$^2$ of flooded tundra, much of which consists of salt-intolerant vegetation.

Numerical modeling has been extended to the Bering Sea. In partnership with Alaska Division of Geological and Geophysical Surveys we have investigated the contribution of varying components to the overall water level that might occur during a storm at three specific sites. Specific locations dictate the relative contributions of astronomic tide, storm surge, and wave runup that might cause flooding. Return period curves, such as the ones in Figure 4, can be used to estimate the frequency and magnitude of extreme events that might cause saltwater flooding.

# IV. Subsurface water flow

Electrical resistivity has proven to be a useful geophysical technique to examine active layer / permafrost dynamics as it is highly sensitive to a change in the ionic strength of pore fluid, mineralogy, and the phase change between liquid water and ice. As part of a combined geochemical and geophysical reconnaissance, multichannel electrical resistivity tomography (ERT) was used to image shallow subsurface features such as permafrost, the active layer, and a coastal bluff face on Barter Island, northeast Alaska. The processed ERT images show dramatic changes in the both shallow and deeper features from June to September, 2014. For example, a shore-perpendicular survey line conducted in September on top of the bluff reveals a thawed active layer that was still frozen in June (Figure 4). During June, when the upper active layer was still completely frozen, many ERT images show pronounced vertical features that are either subdued or not present at all during the September surveys. These features may represent ubiquitous ice-wedge polygon boundaries with unique freeze-thaw cycles. A June-September comparison of such a survey line suggests that ERT effectively captured how the bluff face and tundra sediment changed during one summer thaw cycle. These electrical geophysical methods provide new insights into how subsurface features can change over one summer, with obvious implications to coastal bluff stability and material efflux to the atmosphere and coastal ocean.

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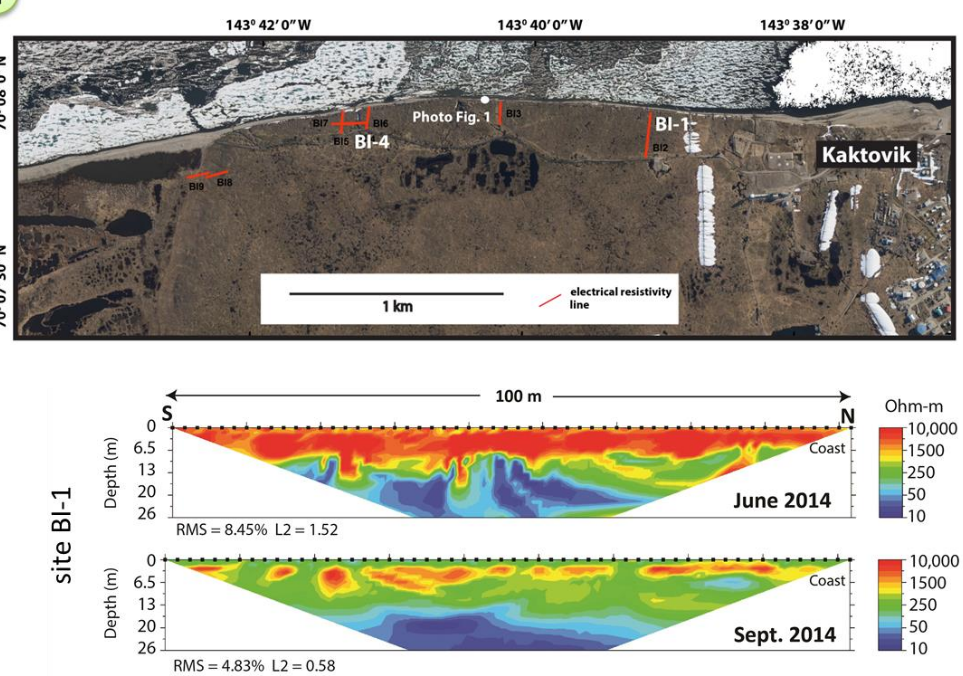


**Upper figure shows electrical resistivity survey lines (red lines) collected along and parallel to the coastal bluffs west of Kaktovik, Alaska in June and September, 2014. Lower figure shows ERT measurements at the beginning and end of summer / early fall for transect BI-1.**