Introduction: Storm surges forming over the extensive shallow shelf of the eastern Beaufort Sea can have significant impacts on human activities and natural ecosystems. The Canadian sector of the region includes the Mackenzie River Delta and a rich and diverse ecosystem. The area supports a vibrant subsistence economy as well as oil and gas exploration, tourism and other industrial uses. This presentation describes aspects of the storm surge climatology and its impacts.

Erosion: Open-water season surges contribute to rapid erosion of un lithified, frozen coastal bluffs with as much as 10-15 m of erosion occurring during a single storm. In many locations surge elevated waves directly impact coastal bluffs causing deep thermal notching followed by collapse of large blocks directly onto the beach.

Winter surges: Winter-season surges also occur, despite complete ice cover, causing pressure ridge development, ice scour, flooding and breakup of ice roads and potential erosion of ice-constrained channel mouths. Ice push, or ice push, associated with winter surges can extend onto land with associated risk to human life and infrastructure.

Analysis of Data and Predictions: Storm surge chronologies are challenging to construct due to a lack of observations and the limited time span covered by the instrumental records. In the Canadian Beaufort Sea, official coastal meteorological and water level records extend back to the early 1960s, although the records are far from complete with very few reporting stations.

Numerical models allow us to fill in missing data and assess the quality of anecdotal reports. The upper figure shows storm surges > 1 m based on modeling using ADCIRC and forced by hindcast winds from 1970-2009. The lower figure shows the spatial distribution of water level during the 1999 storm event.

The Future: Relative sea level in the region is rising due to a combination of local and regional subsidence and sea level rise. Sea ice duration is expected to decrease as the Arctic warms and eustatic sea level rise is expected to accelerate. Therefore, total water levels associated with storm surges are expected to increase. The potential trajectory for frequency and duration of storms is not well constrained by climate model projections. Present variability is too large and the record too short to detect trends, but even if storminess remains unchanged the exposure to damaging surges is likely to increase due to changing sea ice conditions and rising sea level.

The map on the right illustrates the very low coastal gradient and extensive coastal lowlands (< 2 m) associated with the Mackenzie delta region.

An unusual event in 1999 led to the salinization of 200 km² of highly productive waterfowl habitat in the Mackenzie Delta. Impacted areas are easily discernable on Landsat imagery.

Storm surge inundation extent and magnitude for a 2 m surge in the Hamlet of Tuktoyaktuk (based on LiDAR DEM)

The graph on the left shows water levels from Tuktoyaktuk for a surge in January 2005 that was caused by winds exceeding 80 km h⁻¹ (> 20 m s⁻¹). The image on the right shows the clean-up of an Ivu event at Barrow, Alaska (January 2006) that snapped telephone poles and blocked roads.

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<table>
<thead>
<tr>
<th>Storm Surge Event</th>
<th>Date</th>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1944</td>
<td></td>
<td>Tuktoyaktuk</td>
<td>Storm surge inundation extent and magnitude for a 2 m surge in the Hamlet of Tuktoyaktuk (based on LiDAR DEM)</td>
</tr>
</tbody>
</table>

Information from church records, ship’s logs and trading company reports augment the instrumental record from anemometers and tide gauges.

Probabilities of exceedance were calculated using a ‘peaks over threshold’ method. Return periods for peak wind speeds and water levels at Tuktoyaktuk are predicted. Water levels exceeding 2 metres relative to chart datum and winds in excess of 90 km h⁻¹ are shown to be a rare occurrence.

Hudson Bay Company Employee’s Description of 1944 storm at Tuktoyaktuk:

On 27 June, we noticed the water was becoming and continued to rise on the shore bank and up onto the beach. The wind continued to blow from the north throughout the storm and gusting over the village. At 8:00 a.m., a schooner belonging to North Star had been washed up by the storm and pushed up onto the beach. By this time the wind had dropped off, the water still blowing and heavy on seas running. The schooner belonging to North Star was pushed up onto the beach and pushed against the house, store and dwelling house.

Storms, ice, waves, wind and cold temperatures had caused considerable damage. The house on an even keel past the wharf had been washed up onto the beach, blown against the house, store and dwelling house. The schooner belonging to North Star had been pushed up onto the beach and pushed against the house, store and dwelling house.

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