IMPACT OF CLIMATE CHANGE-INDUCED SEA ICE RETREAT ON ARCTIC STORM SURGES

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INTRODUCTION

Canada's Arctic coastline is significantly affected by climate change factors such as relative sea-level rise, thawing permafrost, sea ice retreat, accelerating coastal erosion and increasingly extreme wave climate (Environment Canada, 2019). These factors exacerbate the impacts of storm surges and associated coastal flooding of Arctic communities. While there have been studies studying the impact of sea ice retreat on wave climate (Casas-Prat & Wang, 2020; Waseda et al., 2021), there have not been any studies on its effect on storm surge development.

OBJECTIVES AND NOVELTY

This is the first study quantifying the projected increase in storm surge hazard along the coast of the Beaufort Sea due to climate change-induced sea ice retreat and shortening of ice season duration through numerical modelling.

METHODOLOGY

A numerical hydrodynamic model that solves the Saint-Venant equations was developed using the TELEMAC-2D platform (Hervouet, 2007). The computational domain spans approximately 1000km east-west and 800km north-south and encompasses the maximum extent of open water observed in the Beaufort Sea between 1979 and 2019 (Figure 1).

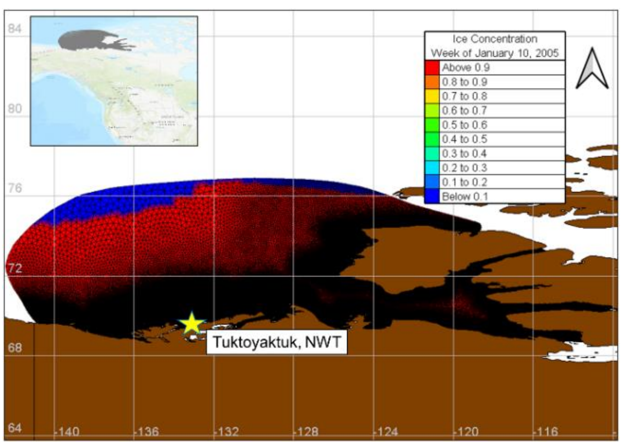

Figure 1 - Computational mesh with mapped ice concentrations for the January 10, 2005, storm surge.

An unstructured mesh with 1.4 million elements was developed with characteristic edge lengths varying from 50km offshore to 500m nearshore. A k-ε turbulence model, Coriolis forces, and constant bed friction were applied. The model was forced by spatially and temporally varying surface winds and pressures from the ERA5 reanalysis to simulate storm surge. The presence of sea ice was accounted for by adjusting the wind drag coefficient (C_d) as per Kim et al. (2021) and Provan et al. (2022) using the parameterization proposed by Joyce et al. (2019). Ice concentrations were obtained from the Canadian Ice Service (CIS, 2006).

Fifty historical storm surge events were identified through a peaks-over-threshold (POT) analysis of water level residuals from a tide gauge located at Tuktoyaktuk, Northwest Territories, Canada. These fifty historical events were hindcasted under actual (historical) ice conditions and an open-water scenario representing future climate conditions with reduced sea ice.

RESULTS AND CONCLUSIONS

The mean percent difference between modelled and measured peak residual (μ) was 14% with a standard deviation (σ) of 52% for the future open-water scenario. μ improved to -7% with a σ of 26% after correcting for sea ice. On average, it was found that winter storm surges modelled under future open-water conditions were 96% higher than when using actual (historical) ice conditions. The event with the most significant difference is seen in Figure 2, indicating that **storm surges could potentially increase as much as three times in magnitude under future open-water scenarios at Tuktoyaktuk.** Additional analysis at other tide gauges in the Beaufort Sea is to be performed.

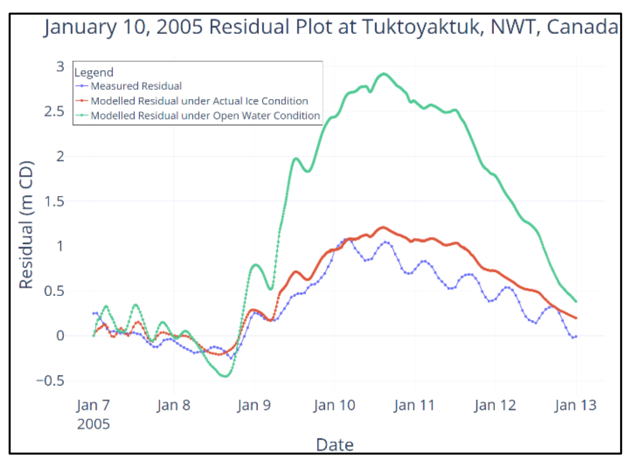

Figure 2 - Storm surge residual plot at CHS Gauge 6485. Residuals are assumed to be representative of storm surges.

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