SURGE AND WAVE CONDITIONS UNDER WARMER ICE-FREE ARCTIC OCEAN

Martin Mäll, Waseda University, mallmartin4@gmail.com
Ryota Nakamura, Niigata University, r-nakamura@eng.niigata-u.ac.jp
Tomoya Shibayama, Waseda University, shibayama@waseda.jp

INTRODUCTION

In the past decade the fast changes within the Arctic basin have become more pronounced. The Arctic amplification has an extremely wide range of global and local implications. The latter has already caused negative impact to coastal communities along the Arctic coastline, where the decreasing annual sea ice extent leaves much of the coastal water open for potential high wave attacks for a longer period of time (Stopa et al., 2017). In return, exposing the low-lying and soft coastline to rapid erosion. The hamlet of Tuktoyaktuk in Northern Canada is one of such settlements that has experienced these rapid changes first hand. Since the changes in Arctic are happening at an accelerated rate, it has become increasingly important to further our understanding of these changes from a coastal engineering perspective. The objective of the current study is to establish a methodology to investigate the surge-wave conditions of individual Arctic extreme storm events of past and future (2050 ice-free Arctic Ocean; Screen et al. 2016).

METHODOLOGY

The core models and flow processes (Figure 1), to a degree, follow that of Mäll et al. (2020). However, in this study the Polar WRF (PWRF; v. 3.9.1), which is a polar-optimized version of the WRF model, is used for meteorological modelling. PWRF is developed by the Ohio State University's Polar Meteorological Group (Hines and Bromwich, 2008). The initialization is conducted with the NCEP Climate Forecast System Reanalysis data and ice parameters are obtained from the Pan-Arctic Ice-Ocean Modeling and Assimilation System (PIOMAS) and interpolated onto meteorological grid data. The PWRF output data is extracted and used as forcing for the FVCOM ocean model where the SWAVE module was included in order to capture the full range of surge-wave dynamics. For creating unstructured grids for the FVCOM model, the 500 m IBCAO v.3 bathymetry data was used. Future simulations were conducted under RCP4.5 and RCP8.5 scenarios for 2050 using 14 CMIP5 GCM ensemble.

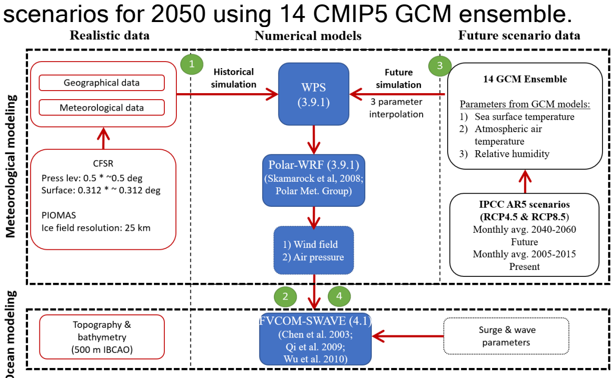

Figure 1 - Flow of models and data for the Arctic study domain.

RESULTS AND DISSCUSSION

Conducting high resolution and spatially accurate modelling studies within the Arctic basin is a challenging undertaking. While great efforts by various research groups have been made to provide suitable tools for such studies, the absence of reliable observational weather, wave and surge data (and high resolution topological data) is a major hurdle when it comes to studying case specific storm events in the Arctic. The 1999 Sept storm used in the study indicated no substantial increase in hydrodynamic response under ice-free Arctic Ocean, instead changes in the Hs spatial distribution were observed (Figure 2). Reasoning for this lies in the different meteorological response between the two scenarios. The RCP4.5 scenario tends to deviate more from the present hindcast simulations. Mäll et al. (2020) studied similar future storm response of extratropical cyclones (ETC) in the Baltic Sea, however the results there were more streamlined. This indicates the need to further extend the scope of the extreme storm studies in the Arctic to reduce uncertainty and improve confidence in such studies.

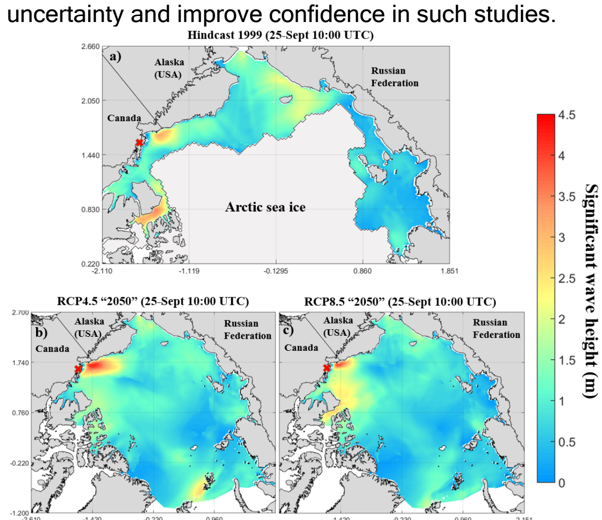

Figure 2 - Hindcast and future 2050 RCP significant wave height modelling results in the Arctic Ocean. The red X marks the location of Canadian port hamlet Tuktoyaktuk.

REFERENCES

Mäll, Nakamura, Suursaar, Shibayama (2020): Pseudo-climate modelling study on projected changes in extreme extratropical cyclones, storm waves and surges under CMIP5 multi-model ensemble: Baltic Sea perspective, Natural Hazards, vol 102, pp. 67-99.
Screen, Deser (2019): Pacific Ocean Variability Influences the Time of Emergence of a Seasonally Ice-Free Arctic Ocean, Geophysical Research Letters, vol 46, pp. 2222-2231.
Stopa, Ardhuin, Girard-Ardhuin (2016): Wave climate in the Arctic 1992-2014, The Cryosphere, vol 10, pp. 1605-1629.