Predicting Future Incident Risk in Arctic Maritime Transit

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While not yet free of ice, transiting along Arctic passageways remains risky, and the sources of risk are multifaceted. They arise from unpredictable and complicated shipping conditions resulting from multiyear ice, ice accretion to vessels under extreme low temperature, floating ice and bergy growlers, surge, and more. As these risks abate, an increase in vessel traffic, including cargo traffic, can be expected. Estimates of potential risks under such changing shipping conditions can support investment and preparedness decisions by governments, the local authorities that ultimately carry the burden of search and rescue when required, and carriers in strategic planning for future Arctic operations. While increasingly passable passageways may benefit private industry, the increased traffic may also negatively impact the environment and marine life, ultimately affecting the ability of animals and local people to subsist. Whether considering investments needed in Arctic infrastructure and service capabilities and capacities or planning for how to protect the environment and sea life, the ability to predict traffic levels under future conditions, which relies on shipping risk estimates, is needed. This work has culminated in the needed Arctic incident risk estimation and prediction tool.

The Arctic incident risk estimation and prediction tool was developed on concepts of data-driven Bayesian networks (BNs). Key to the training of the BN was input from over 5,000 incidents in the Compendium of Arctic Ship Accidents (CASA) incident dataset from the Arctic Council and Protection of the Arctic Marine Environment (PAME). Causal relationships between environmental conditions and incidents, along with expert judgement, were used to construct the BN using a score-and-search K2 learning algorithm for identifying a best network structure. Once trained, the tool predicts both short- and long-term incident risks given predicted navigation conditions.

To develop predictions of incident occurrence probabilities and consequences across key subregions of the Arctic Ocean for 2020 to 2070 by season, seasonal predictions were made under changing environmental conditions given probabilistic climate predictions obtained from the CNRM-CM6-1-HR climate model and supplemental modeling capabilities that provide high-resolution dynamic downscaling of sea ice and simulate ocean wave hazards for the period. For the given climate projection, the outputs of the model are estimates of future incident risk of transiting key Arctic-based routes.