Catalyst Grant Final Project Report

Project title: *Knowledge co-production in effective communication of Great Lakes ice forecasts*

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Summary
In the North American Great Lakes, lake ice that forms during winter often poses challenges in navigation safety. The shipping season is largely restricted to the ice-free period in the lakes (April–December) or when aid can be provided by U.S. and Canadian ice-cutting vessels. However, for the vessels that continue to operate during ice-covered periods, accurate information on ice extent, concentration, and thickness is crucial to ensure safe navigation. There are existing satellite- and model-based products that inform vessel operators with Great Lakes ice conditions. However, the current gap in these products is the short-term forecast capability that provides a prediction a few days in advance. To fill this gap, the development of the short-term Great Lakes ice forecast model is underway to be added to the existing NOAA's Great Lakes Operational Forecast System (GLOFS). While this upcoming product should help improve winter mariners' decision-making in determining shipping periods, navigating ice-covered lakes, and planning ice breaking operations, a critical condition for this is that the user interface of the upcoming ice forecast product provide usable information for the mariners.
In this context, the project team funded by the Catalyst Grant conducted a proof-of-concept study of knowledge co-production in the Great Lakes ice forecast, with the main activities of hosting a stakeholder engagement workshop with two targeted stakeholder groups, the Lake Carriers' Association and U.S. Coast Guard, as well as a need-assessment survey. During the workshop, total 27 invited participants from the shipping industry, U.S. Coast Guard (USCG) 9th District, NOAA, and the University of Michigan engaged in facilitated discussion, science presentation, and world cafe activity. The need-assessment survey was also conducted for a broader number of vessel operators from the shipping community and USCG 9th District. The findings from the workshop and survey were analyzed in a structured way to generate actionable recommendations to the user interface of the upcoming short-term ice forecast product from GLOFS, as well as recommendations for the long-term model development. Key findings include the stakeholders desire near-real time information at a sufficient temporal frequency, with the capability to focus on important geographic areas, such as connecting waterways, and coordination with the existing ice information products.
The findings underscore the importance of continuing in-depth interactions among the key user groups, the decision makers on the user interface at NOAA, and the model developers at the university and NOAA Great Lakes Environmental Research Laboratory.

Project background and approach

As extreme weather events become more frequent with climate change, forecasts should be easy for the public to use. In the Great Lakes, severe ice cover has direct socioeconomic impacts on commercial shipping and navigation safety (Lake Carriers' Association 2019). As such, accurate forecast information of lake ice conditions would mitigate these impacts, from enabling shipping community to plan their operations effectively to helping U.S. and Canadian Coast Guards with planning their ice breaking operations. However, an important condition for achieving this is that the forecast product provides usable interface for their decision-making.

Currently, the capability of short-term forecast of Great Lakes ice conditions is missing. To fill this gap, the development of an ice forecast model is underway to be added to the existing NOAA Great Lakes Operational Forecast System (GLOFS, Anderson et al. 2018), which provides nowcast and forecast guidance of lake conditions including lake surface temperature, currents, and water. The GLOFS research-to-operations (R2O) transition will continue through 2022, and within this timeframe the short-term ice forecast guidance will be implemented into GLOFS. To ensure that the upcoming ice forecast guidance will provide usable information to help the Great Lakes mariners with their decision-making, it is critical to understand what decisions users make with ice information, what variables users need for their decision, and what type of communication is most usable.

In this context, the project team conducted a series of stakeholder engagement efforts, with the main activity of hosting a needs assessment workshop with two targeted user groups, the Lake Carriers' Association (LCA) and U.S. Coast Guard (USCG) 9th District, as well as a need-assessment survey. The overall goal is to formulate recommendations on the design of the user interface of the upcoming ice forecast guidance from GLOFS.

External partners
The external partner, Tom Rayburn, is the Director of Environmental and Regulatory Affairs for the Lake Carriers and Association (LCA). Mr. Rayburn represented the Great Lakes commercial maritime community for this project, with his interest in a fresh look at data compilation, sharing, and use of Great Lakes ice information, which is critical for the Great Lakes mariners. Mr. Rayburn advised on the development of project materials, speaking for the interests and concerns of Great Lakes shipping vessels, as well as helping with participant recruitment in the workshop and survey.

Activities
The stakeholder engagement workshop was held at the City Club of Cleveland, Ohio on July 11, 2019 with 27 participants, consisting of 9 representatives from the target user groups (LCA and USC G 9th District),12 participants from NOAA organizations (local Weather Forecast Offices, National Ocean Service, National Ice Center, and the Great Lakes Environmental Research Laboratory), and 6 participants from the University of Michigan. The workshop started at noon with a social lunch, followed by a facilitated panel discussion with target stakeholders, a science presentation on Great Lakes ice forecast model development, and a world cafe data collection activity inviting participation from all workshop attendees. With the informed consent of participants, workshop discussions were recorded, transcribed, and coded using Conventional Content Analysis(Hsieh and Shannon 2005)
The survey was mainly designed to aid answering the questions addressed during the workshop. The survey was implemented online using Qualtrics software (Qualtrics, Provo, UT), sent out to the targeted user groups (LCA and USCG 9th District) on July 2, and was closed on September 12th. A total of 67 valid surveys were collected 43 from LCA and 24 from USCG 9th District.

Findings
Key findings from the workshop and survey include that the stakeholders use ice information to decide whether it's safe to navigate during ice conditions for the following purposes: shipping, ice breaking, emergency response, rescue missions, law enforcement operations, and buoy retrieval; that the stakeholders desire near-real time information at a sufficient temporal frequency, with the capability to focus on important geographic areas, such as connecting waterways; that coordination with the existing ice information products, such as Daily Ice Briefing from the USCG 9th District, would be important; limited

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bandwidth over the lakes could be an obstacle to access to sophisticated web-interface offshore; and that the stakeholders expressed satisfaction with the overall co-production effort in the project and their willingness to participate in similar activities in the future.

Outputs
The major project output is the workshop report that summarize the stakeholders' perception on what decisions the mariners make using the ice information in the Great Lakes, what ice information the mariners use to support their decision-making, and what the stakeholders require for a short-term Great Lakes ice forecast. The workshop report includes recommendations on the user-interface of the upcoming ice forecast guidance from GLOFS, which are primarily addressed to NOAA-affiliate organizations that are involved in operations of GLOFS, Great Lakes ice information, and the model development, which are, National Ocean Service, National Ice Center, and CIGLR. Representatives from these organizations also participated in the workshop.

Publications:
Fujisaki-Manome, A., et al. "Simulating impacts of precipitation on ice cover and surface water temperature across large lakes." *Journal of Geophysical Research: Oceans*: e2019JC015950.

Final workshop report: https://graham.umich.edu/media/files/Great-Lakes-Ice-Forecast-Workshop-20191105.pdf

Presentations:
- Co-I Gill presented the workshop's findings at the annual international ice breaking conference hosted by USCG 9th District on October 30, 2019.
- PI Fujisaki-Manome presented the project findings along with the ice forecast model development at the American Meteorological Society's 10th Conference on Transition of Research to Operations in Boston MA, in January 2020. A review of that presentation is available here: https://ams.confex.com/ams/2020Annual/webprogram/Paper368062.html

Outcomes
The project launched a co-production effort in research-to-transition (R2O) efforts of GLOFS. The importance of continuing engagement of stakeholders with structured methods supported by social science was recognized. As supported by the pre- and post- workshop evaluation survey, the stakeholders were satisfied with the workshop activities and expressed their willingness of being involved in the future stakeholder engagement activities to co-develop of Great Lake ice forecast guidance from GLOFS. An CLaSP undergraduate student, who was supported by the project, obtained experience with creating forecast graphics and co-production approach. As unanticipated outcome, the project led to an additional funding from NOAA's Climate Program Office (CPO) to scale-up the project work, engaging a broader range of stakeholders, training a postdoc and students, and publishing papers in a peer reviewed journal(s). In addition, CIGLR and GLERL anticipate developing new social science proposals on the R2O effort of the Great Lakes ice forecast to relevant NOAA funding opportunities.

Evaluation
- Implementation of the proposed work was conducted in a proposed timeframe. The workshop report is still to be finalized after reviews by the stakeholders. The project team anticipates that the review process should complete by the end of October.
- As the measures of success from the proposal, the project team conducted an evaluation survey to stakeholders. Evaluation metrics were informed by knowledge co-production evaluation indicators developed by Wall et al. (2017), and by the barriers and opportunities identified by Lemos et al. (2012). The target stakeholder participants were asked to participate in pre and post evaluation surveys to assess their perceptions of the proposed forecast and the workshop itself. Overall, participant understanding of the goals and their role in the project increased after participating in the workshop. Post-workshop, Most participants reported that they have a strong understanding of their role. Participants reported a strong willingness to the use forecast, because they thought that it would be useful. All participants reported that the workshop was beneficial. The detail results of the evaluation survey are included as Appendix D in the workshop report.

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