DAVE: A geospatial tool to better anticipate ice jams

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Context and objective

R&D project
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(3 years)

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Centre for Security Science (DRDC)

INRS UNIVERSITÉ DE RECHERCHE
Gouvernement du Canada
Sécurité publique Québec
Defence Canada (DRDC)
Natural Resources Canada
Environment and climate change Canada
Public Safety Canada

*DAVE is the French acronym for « **D**ispositif d'**A**lerte et de **V**igilance aux **E**mbâcles de glace »*

In Canada, a great proportion of floods are caused by river ice jams. These floods have repercussions regarding public safety and damages to infrastructures and buildings. Understanding and modeling of ice jam physical processes have been and are still extensively studied. Despite this effort, due to the nature and complexity of the phenomenon, there are very few operational tools to predict the breakup of ice cover and the subsequent formation of ice jams.

Objective: To develop a tool to better anticipate ice jams across the country by integrating three levels of information:

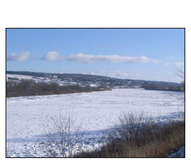
- the current conditions of the ice cover;
- the hydro-meteorological patterns associated with an imminent and problematic breakup;
- the channel's predisposition to ice jams.

The underlying approach

The ice jam principle could be compared to a rock or snow avalanche. This guides the approach of the DAVE system.

Principle	Conditions	Approach	Tools	Output
Material available to be moved	Weakened ice cover	Determining ice cover characteristics	Satellite imagery, drones, citizen sensors	Ice cover status indicators
Triggering factors	Favorable hydro-meteorological conditions	Detecting hydro-meteorological patterns	Statistical model	Signs of imminent breakup
Gradient and path	River channel with obstacles and restrictions	Identifying predisposed river sections	Geospatial model	Areas at greater risk

The DAVE system



Quebec's historical ice jam database

Sécurité publique Québec

- Compiled from digital or paper documents, from event or situation reports;
- More than 900 entries;
- Events on 40 rivers;
- Records since 1980;
- Quantitative and qualitative data.

The challenge of such a system is to take into account a variety of intrinsic and dynamic factors at different spatial and temporal scales, and from historical databases, forecasting models or real-time data sources. The proposed approach is, therefore, **data oriented** and will cover multiple rivers. The system will first be developed for the province of Quebec, making use of its unique historical ice jam database.

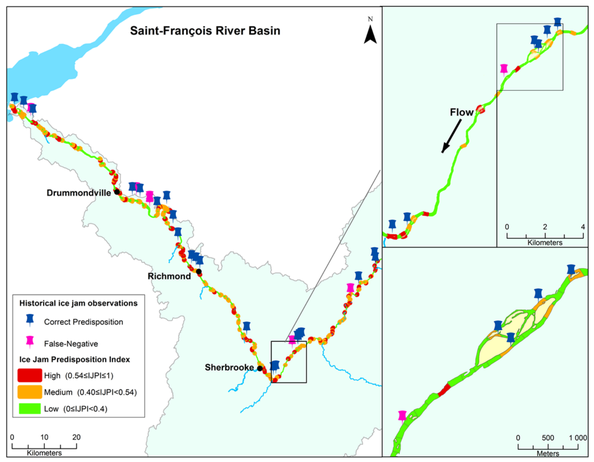
Methodology

Component 1: An advanced geospatial ice jam predisposition model

Based on: *De Munck, S., Gauthier, Y., Bernier, M., Chokmani, K., and Légaré, S.: River predisposition to ice jams: a simplified geospatial model, Nat. Hazards Earth Syst. Sci., 17, 1033-1045, https://doi.org/10.5194/nhess-17-1033-2017, 2017.*

Rather than predicting the timing of river ice breakup, the main question here is to predict where the broken ice is susceptible to jam based on the river's geomorphological characteristics.

Simplified model	Advanced model
The presence of an island	A slope break
The narrowing of the channel	An attenuating factors (rapids)
A high sinuosity	The shape and length of the contributing reach
The presence of a bridge	A sudden channel widening
The confluence of rivers	The presence of hydraulic structures

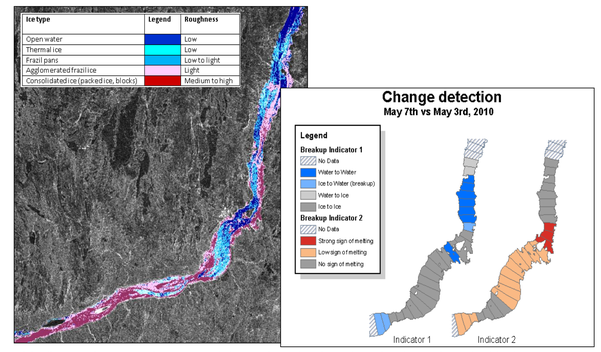


Map of the model results on the St-François River, over 250m sections. Thumbnails are the locations of reported ice jams. Blue is used when the ice jam falls on a section with a moderate to high predisposition (correct assessment). Magenta is used when the ice jam falls on a section with a low predisposition (false-negative error). *From De Munck et al, 2017.*

Component 2: Algorithms to determine ice cover characteristics

We are looking for: presence of ice, type of ice cover, signs of deterioration. Information will come from:

- Radar and optical satellite imagery (based on the work from INRS, BC Hydro, NRCan and others). Ensemble processing can help to achieve more reliable results.
- Crowdsourced geographic information - CGI (based on the work from NRCan). CGI observations can seed a second iteration of image processing to improve initial ice maps.
- Drone surveys can be used to better characterize a specific ice event in a sector flagged by DAVE.

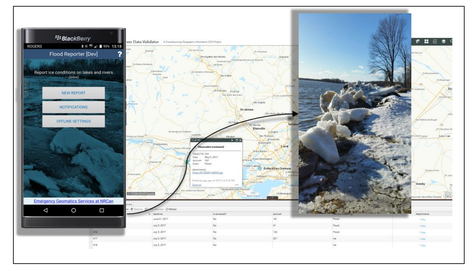


This figure shows an ice map of the Koksoak River (Quebec) produced with the IceMAP-R algorithm (INRS). From two ice maps from different dates, the change detection tool (INRS) was used to locate areas where the breakup is underway. *From Gauthier et al, 2012.*

Component 3: A stochastic model to identify hydro-meteorological patterns

Based on the analysis of the Quebec's historical ice jam database, we will try to identify patterns that could be favorable to induce a breakup which can lead to an ice jam.

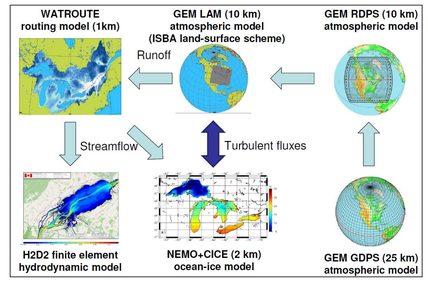
Environment and climate change Canada (ECCC) will provide past hydro-meteorological data, as well as an archive of three-day forecasts of river discharges starting in June 2016 at the 1km scale for the Great Lakes and St-Lawrence basins (upstream from Tadoussac). This is produced by WCPS, a coupled atmospheric, hydrological and hydrodynamic models. It will cover other basins in a short future. Therefore, DAVE could eventually be applied Canada-wide.



Crowdsource geographic information application developed at Natural Resources Canada. *From Decker et al, 2017.*

Integration

An important part of the project will be to determine how to integrate all components to assess the risk of ice jam, what kind of warning should be issued and whom it should concern. DAVE will be deployed on all rivers prone to ice jams in Quebec. It is developed for operational use within the Emergency Geomatics Service of NRCan and within the river surveillance program (Vigilance) at the Quebec's Public Safety Ministry. Two PhD students, one post-doc fellow, one research associate, one MSc student and several undergraduate students have already been recruited for the project.



Environment and Climate Change Canada's Water Cycle Prediction System (WCPS) for the Great Lakes and St. Lawrence River. *From Fortin et al, 2017.*

CRIPE 19th Workshop on the Hydraulics of Ice Covered Rivers, Whitehorse, Yukon, Canada, July 9-12, 2017.

Acknowledgements

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