Mapping of river channels prone to ice jam formation

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1. Context

Ice jams (IJs) in Canada lead to flooding upstream of the ice front, which represents a major geohazard for riverside populations and requires that prediction methods be developed to provide early warning.

This study is part of the DAVE project, funded by the Defence Research and Development Canada's (DRDC) Canadian Safety and Security Program (CSSP). **The goal of the DAVE project is to improve ice jam risk management across Canada.** DAVE is the French acronym for « Dispositif d'Alerte et de Vigilance aux Embâcles de glace »

The combination of hydrological, meteorological and geomorphological variables is essential for spatial location and forecasting the date of an IJ.

The DAVE system

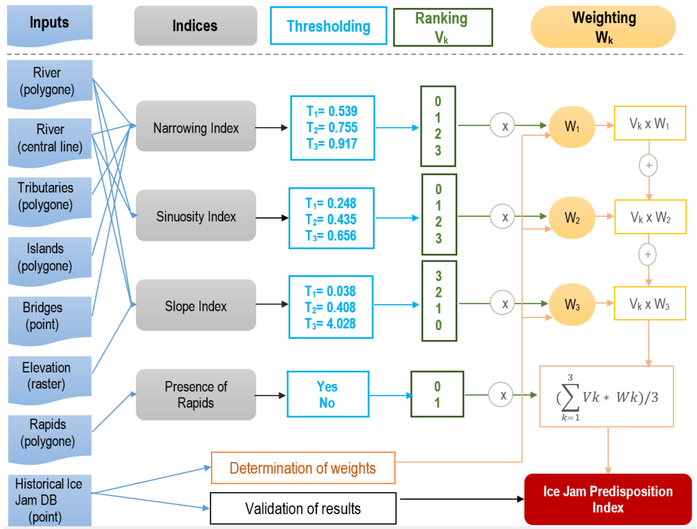
2. Objectives

- Locate areas prone to IJs formation in the main rivers of the Province of Quebec (11 rivers having a high IJ occurrence).
- Improving the existing Ice Jam Predisposition Index (IJPI) developed by De Munck et al. (2017) on three rivers in the Province of Quebec: the Chaudière River, the Saint-François River, and the L'Assomption River.

  By integrating new geomorphological factors, in particular the presence of rapids and channel gradient.

3. Methodology

Conceptual diagram of the ice jam predisposition model



Tested versions of the model :

v01a	Existing model (De Munck et al 2017)
v02a	Existing model And Risk= low in rapids
v03a	Model v02a And Risk = high after rapid And Risk increased by 1 in the 2 sections adjacent to a high risk section (one upstream and one downstream)
v04a	Model v03a + integration of the slope index
v04b	Model v04a by increasing the risk by only 1 upstream of a high-risk section

Validation metrics :

Confusion matrix		Estimated	
		Negative	Positive (Ice Jam)
Observed	Negative	True negative	False positive
	Positive (Ice Jam)	False negative	True positive

Total of real positives (observed)

$$\textbf{Overall Accuracy}_{\text{segment}} = \frac{True\ positive + True\ negative}{True\ positive + True\ negative + false\ positive + false\ négatif}$$

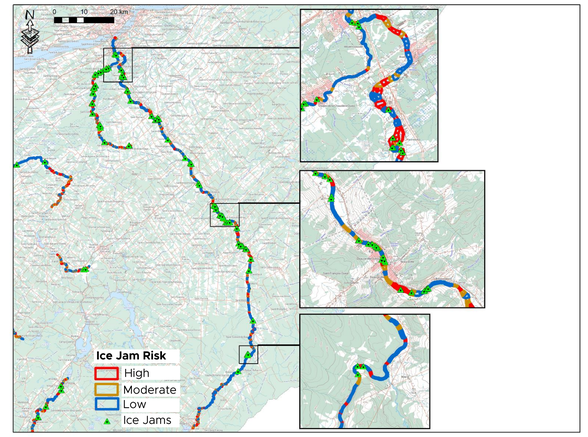
$$\textbf{Recall}_{\text{segment}} = \frac{True\ positive}{True\ positive + false\ negative} = \frac{Vrai\ positif}{\Sigma\ real\ positives}$$

$$\textbf{\% TP}_{\text{ice jam}} = \frac{True\ positive}{True\ positive + false\ negative} = \frac{True\ positive}{\Sigma\ Ice\ jam}$$

$$\textbf{\% FN}_{\text{ice jam}} = \frac{False\ negative}{True\ positive + false\ negative} = \frac{False\ negative}{\Sigma\ ice\ jam}$$

4. Results

Results of the model on the Chaudière River



Results of the validation of the different versions of the model

Model	Overall accuracy	Recall	By 250 m segment (section)								By Ice Jams	
			TP	% TP	FP	% FP	TN	% TN	FN	% FN	% TP	% FN
v01a	0.64	0.46	117	0.02	1951	0.33	3652	0.62	136	0.02	0.47	0.53
v02a	0.69	0.45	115	0.02	1703	0.29	3900	0.67	138	0.02	0.46	0.54
v03a	0.57	0.66	167	0.03	2430	0.41	3173	0.54	86	0.01	0.69	0.31
v04a	**0.54**	**0.71**	**180**	**0.03**	**2646**	**0.45**	**2957**	**0.50**	**73**	**0.01**	**0.74**	**0.26**
v04b	0.62	0.62	158	0.03	2132	0.36	3471	0.59	95	0.02	0.65	0.35

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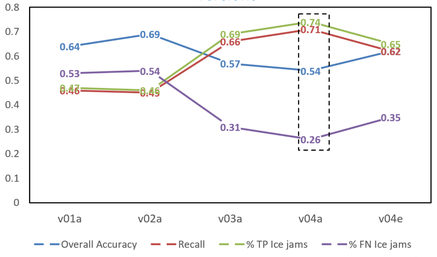
Results of the validation of the chosen model v04a by river

River	Overall Accuracy	Recall	By segment (section)								By ice jam	
			TP	% TP	FP	% FP	TN	% TN	FN	% FN	% TP	% FN
Assomption	0.40	0.77	20	0.03	401	0.59	254	0.37	6	0.01	**0.80**	**0.20**
Beaurivage	0.52	0.67	16	0.06	114	0.45	117	0.46	8	0.03	0.67	0.33
Becancour1	**0.58**	**0.73**	11	0.02	237	0.42	318	0.56	4	0.01	**0.77**	**0.23**
Becancour2	0.47	0.50	1	0.01	37	0.51	33	0.46	1	0.01	0.50	0.50
Chateauguay	**0.53**	**1.00**	16	0.05	151	0.47	152	0.48	0	0.00	**1.00**	**0.00**
Chaudière	**0.59**	**0.83**	43	0.05	333	0.40	447	0.54	9	0.01	**0.85**	**0.15**
Montmorency	0.67	0.53	9	0.03	97	0.31	201	0.64	8	0.03	0.59	0.41
Nicolet	**0.54**	**0.63**	10	0.02	248	0.45	288	0.52	6	0.01	**0.72**	**0.28**
Ristigouche	0.45	0.53	9	0.03	137	0.52	109	0.41	8	0.03	0.54	0.46
Sainte_Anne	0.44	0.77	10	0.02	254	0.55	191	0.42	3	0.01	**0.75**	**0.25**
St_Francois	0.53	0.64	21	0.02	387	0.46	424	0.50	12	0.01	0.63	0.37
Yamaska	**0.62**	**0.68**	15	0.02	260	0.37	413	0.59	7	0.01	**0.71**	**0.29**

Performance of the v04a model compared to other versions



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DRDC RDDC

Défense nationale National Defence