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Earth System Science Data Discussions

Interactive comment on "A Canadian River Ice Database from National Hydrometric Program Archives" *by* Laurent de Rham et al.

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Dear Authors,

I am pleased to provide a review for this paper. It represents a tremendous amount of work and a significant publication that will generate a positive impact on river ice research in years to come. I will definitely use the CRID and it will soon become a widely understood acronym within the river ice community and Canada and abroad. I know how it feels to analyze hundreds and hundreds of data sets, and then having to do it again in the most consistent way possible because of the need to to add another winter variable.

General comments:

- The tone of the introduction could be slightly adapted (see specific comments). It is true that this type of publication and database has not been seen in the past, but I believe that the absence of a CRID before now never prevented meaningful research to be completed and published. The hydrometric data has always been accessible and it was analyzed as needed. A research paper about ice processes at a specific location is valuable and should not be overlooked because it only includes data from a single or a handful of sites.

- The authors could state more formally (in the Data Disclaimer, but also elsewhere in the paper) that even a data rating of 0 may not replace the Engineer's professional responsibility for the conception of flood maps and for the design of hydraulic structures.

Specific comments: The sum of the experience of all authors is spectacular, and these comments will hopefully be perceived as constructive. Most of them are suggestions. There are lots of comments, but I am really taking this at heart and hope that this publication can be as perfect as possible.

Lines 17-18: This is a typical expression used on the Canadian West Coast, in Southern Ontario or in Eastern and central United States. River ice is not only common in cold regions, it is a part of the annual cycle, like open water conditions. I suggest rewording this.

Line 18-19: Not sure why this sentence is here. There has been papers focusing on many sites and many rivers. In turn, there is a reason why specific reports try to address local issues. In both cases, the Canadian data base would be useful

Line 36: Why not saying : River ice processes are an intrinsic component of cold climate watersheds.

Lines 37-41: The authors could refer to CRIPE at this point in the introduction. This Canadian research group on river ice has been quite active and productive since the 1980.

Line 42: Following the general comment #1, I am not sure why this sentence starts with "However"

Lines 43-44: This is not necessarily true. Researchers have been extracting the data that they needed, most of the time. It has just not been done in a consistent way.

Line 50: "calculating" could be "estimating". Using "calculation" may insinuate that the result is exact, which is not the case.

Line 50-52: This is the main point of the paper.

Lines 69-77: Note that these examples are all from the Mackenzie basin, and then, the following paragraph is about outside Canada. Should there be a short mention of river ice studies in other watersheds in Canada before initiating the following paragraph?

Lines 90-93: This comes back to Canada. Scandinavia is not mentioned in this paragraph. They must have done similar work, and if not, it could be mentioned.

Lines 99-101: Indeed, no one has ever done an extraction of all river ice variables on so many Canadian rivers. This should not be expressed as a weakness from the literature, but as a strength of this research to support other research and development. This paper is strong enough to avoid falling on the classic message about the need to fill obvious gaps in the literature.

Line 168: Can you please double-check that Groudin is not Grondin (a more common name)? Also in Table 1. You may very well be correct.

Line 194: Is "potential" the right word here? My understanding of potential is what can be reached or achieved at a site or station, as opposed to the fine-scale maximum at a station for any given year.

Line 197: Should "daily" be "daily-averaged"?

Line 199: Should "depends" be "depending"?

Figure 3: You could clarify this figure by adding the duration of the ice season. I am not sure that the title of the X axis is accurate. This cannot be a complete year, at least not if the scale is constant. Last B date is quite low compared with HM. Is this a typical behavior? I like that HO is significantly lower that HM, but again, is this typical? It just seems that so much water has been flowing during breakup and that the freshet is almost over by then. I understand that this may be representative of a specific river, but is this largely applicable / representative of Canadian River?

Figure 3: The peak to and from HM is intriguing to me. It is a relatively gradual rise, which does not suggest the formation of an ice jam. Then, the water level drop does suggest the gradual thermal melting of an ice jam. Also, in my mind, Last B date should be at higher level than HB, but I may be wrong.

HLQ1:Not sure if this is well positioned in Fig. 3. It seems that after freeze-up, thermal thickening or thermal erosion should follow. Therefore, I do not see why this first minimum Q would occur during the subsequent rise in water level. I may be wrong and you may have seen this at some stations.

Table 2: First B date (and last B date): Has this been re-analyzed or indicated B dates were just adopted as they appeared in reports? My understanding is that B dates are often off by a few days and this can be checked with some temperature and hydrological indicators. It can have a significant impact when preparing flood maps that distinguish different flooding processes.

HF: This is quite obvious when the ice cover forms by frontal progression, but the gradual formation of border ice followed by ice congestion in a relatively narrow open water channel may not generate a clear signal. That being said, there would most probably always be a "maximum freeze-up level", and this may be a more appropriate name for this parameter. (I am unsure how you would differentiate that from a small runoff event taking place during freeze-up and generating or not, a freeze-up jam.). I appreciate the explanation provided at lines 362-368.

HF2: Could change the name of this variable to "water level at second freeze-up"

Line 258: Drifting ice is part of the flow, it is not stagnant ice, and it should not generate backwater if the surface concentration remains low. Same comment for flowing ice chunks.

Line 284: I am unsure why point C is not at the first spike that seem to be sharp enough to represent a local ice movement, possibly a downstream partial breakup that would reduce backwater at the station.

Lines 290-291: I believe that hydrological simulation, comparison with other stations, or judgment can still provide some kind or error margin (it can hardly be more than one order of magnitude, at least).

Lines 307-311: Not sure if this paragraph invites CRID users to report on possible errors that could justify specific re-analyses. I believe that it should be the case, but it depends on how ECCC will want to maintain and update the CRID.

Line 327: The authors could confirm if this first B date on Oct 10 was the result of a rise in water level that trigger the decision to initiate B condition. More generally, the authors could confirm the information (cameras?) or signs (rise in water level after X degree-days of freezing) that are usually considered to initiate B conditions.

Figure 5: Adding the water level signal to this figure would be of interest, but it does represent some work.

Lines 351-352: The authors could mention something about peak factors (instantaneous divided by daily-averaged) here. For freeze-up, peak factors can be in the order of 1.1 or 2.0, depending on freeze-up dynamics... This would just be a reminder that using a 1 for design may be unsafe.

Line 367: The authors could mention that this can take place over a distance of several hundred km upstream.

Line 371: "...snow and..." First time I see this expression. In some regions, there is snow, but no ice cover because there is too much heat (downstream of lakes or reservoirs, or maybe downstream of cities and industries). Still, the word "snow" here may create confusion since this paper is about the ice cover period.

Lines 377-379: It could be mentioned that this is common and mostly caused by the thicker ice cover at the end of winter that generates a higher water level despite this being the actual winter min Q.

Line 383: "analysis" is probable "analyses" (plural)

Line 396: "risk" and "threats": The risk cannot be a threat. Consider rephrasing this considering that the risk is a combination of consequence and probability (or possibility) of a hazard and that a threat is in this case a hazard.

Lines 400-401: There are also records from nearby hydrometric stations.

Line 407: Not sure if a sudden drop in water level can be considered as a "spike". Also, depending on where the station is located and about the intensity of the winter runoff events, the water level signal can be a drop (local breakup) , a gradual rise (ice cover is lifted), a sudden rise (ice jam formation), or a combination of the aboves.

Line 411: In areas where multiple mid-winter breakup events occur, they can be hard to distinguish from freeze-up chaos. First question: Does a mid-winter runoff event only qualifies after a complete ice cover has formed? Second question: why not using the highest mid-winter peak instead of the first one? Third question: How would you consider a massive breakup event at the end of February like it happened in 1981 in southern and central Quebec? Would that be a mid-winter breakup followed by no more winter, or would that be the spring breakup event? I am curious, but understand that we may not have to start a conversation about this.

Lines 414-415: I am not too familiar with WSC's practice, but I would be very careful to remove a B in the middle of winter following a mid-winter breakup event. This may

occur in NE, NB, southern QC and ON as well as in West-southern BC, but in most of Canada, after a complete mid-winter breakup, the presence of shear walls would prevent the removal of the B until the flow has receded significantly and this is when a cold spell may have already created border ice.

Line 431: "mark": I would say "may mark" as this is not the case for all types of rivers.

Line 435: Depends where: In some cases, a mid-winter breakup event is followed by a dramatically cold period during which frazil generation is significant. The result may be a very thick ice accumulations, with inflated ice jams and new anchor ice cycles.

Line 436: Of course, daily-averaged levels may appear smooth enough. At specific locations, the water level could remain high or even increase even though the discharge drops. This would be caused by progressive frazil accumulation produced in a newly open (steep) reach exposed to cold air. Hydrometric stations are usually not located in reaches affected by this type of process. I am just providing this information in case it would seem appropriate to adapt the text (and this applies to many other comments).

Lines 450-452: A hanging dam can form several km downstream of an open reach. It all depends on the river gradient and profile. In the case of anchor ice, it can hardly remain in place for several months. It will either contribute to the formation of a complete surface ice cover, or will melt away during mild spells and come back during cold spells. I suggest that this creeping signal is mostly associated with frazil accumulation.

Lines 452-453: But wouldn't it still deplete during the winter time? I see that you have a reference at the end of the sentence but does that reference suggest that?

Figures 8 and 9: A superposed air temperature graph would be of interest.

Line 471: Please update Figure #

Line 485: "Impure ice": Is this common? Should you explain what this means in brackets? Should you also add this to the previous sentence that refers to snow load, for consistency?

Lines 504-506: You may suggest that readers could take the measured thickness and associated date, evaluate the corresponding cumulated degree-days of freezing (or a cumulated sophisticated heat budget), and create a relationship between both parameters. Step 2 would simply be to apply this relationship to the maximum degree-days of freezing of each winter to obtain an estimate of the maximum ice thickness (if no mid-winter breakup occurred between ice thickness measurement and actual max freezing degree-days).

Lines 517-518: Actually, the station may start "feeling" some stage instabilities that come from upstream (these would actually be discharge instabilities induced by upstream ice movement), and it would still mean that breakup has initiated. How do we know that this is taking place downstream, especially when looking at daily-average stage data?

Line 518: Same comment as before: a reduction in roughness would generate a sudden drop of the instantaneous stage signal. In turn, a jave would be a spike and a sudden raise would be the formation of an ice jam downstream.

Line 529: I am not sure that there is a need to state "quickly" here. First, it applies to both time and distance traveled. Second, quickly is relative and I have seen large ice slabs (especially those that were part of a hanging dam or a snowmobile crossing) remaining fairly large several days or km after breakup.

Line 532: Should there be an example of a case study reporting X meters above the rating curve? This would illustrate the meaning of "far exceed"

Lines 534-535: This is not exact: They can also cause a measurable stage (actual discharge) depressions for several hours before reaching an equilibrium. The jave is much more sharp, especially in steep channels and when the released jam was not too far upstream from the station.

Lines 535: It should be stated that 1. Javes can only be adequately documented using

instantaneous data. 2. Javes have probably been removed from discharge records (at least in Quebec) as they were considered to be ice jams that had nothing to do with a discharge signal. It is also possible that javes and ice jams have been removed from some records because they were perceived as instrument pathologies. If there is enough evidence of this practice in some offices, the authors should mention it in the discussion.

Line 541: Could be completed by "... where the stage gradually returns to the stage-discharge relationship as the discharge slowly increases"

Line 550: Should the authors state that the last B date could likely be off by a few days? It is not to criticize the work done by different offices, but to warn users about this possible limitation. The last B date is specially difficult to confirm during thermal breakup years or when post-break ice runs from far upstream still occur after a complete local wash.

Figure 12: Second image is very dark. Is there a way to tweak this?

Line 575: Should the authors mention that Ho may actually occur in mid-summer (e.g., Saguenay event in Quebec, 1996) or during the fall, and therefore may not be associated with the spring freshet, especially in Eastern Canada?

Line 577-578: Just to complete the idea, i would suggest: "...for a large ratio of hydrometric stations in Canada, and most probably for an equal ratio of unmonitored sites."

Line 584: "five" should probably be "six"

Line 605: Should the author specific what defines an error or what it the calculation behind this %?

Lines 606-607: It is unclear to me if indicated B dates are considered true and other parameters are corrected consequently, or the opposite.

Lines 613-614: As asked earlier, would the authors also commit to present updated

versions of the CRID with corrections?

Lines 623 vs. line 634: If I had to choose, I would say that ice processes are site specific.

Line 628-629: (e.g. promoting a thicker ice cover in the deck shadow and promoting ice jamming against abutment or pillars)

Figure 13: The legend in this graph could include variable acronyms for clarity. Also, it would have been useful to separate the two populations with different icons / colors. The only obvious difference is the two populations is blue circles.

Table 4: There may not be enough space, but the authors could consider adding a column with the variable acronym.

Line 694: "Very often" Do we have an updated number about that? If not, I hope that the CRID will be used by researchers to update the one third presented by Beltaos years ago.

Line 694-695: I am not sure that I agree with this interpretation. It can be said that ice jams produce higher water levels at similar high flows (quite logical), and it can be said that at some sites, the main flooding process is caused by ice processes. In turn, the highest discharge in rivers most often occur in the absence of ice. There should be a more efficient way to express this.

Line 696: "eg." should be "e.g.". I take note that FloodNET is only one example. Other groups have completely ignored river ice processes in their flood research.

Line 700: "could likely" should be "should, when applicable,"

Line 701: For sites that are not included in the CRID and where winter water level information is available, the CRID can represent a template to extract pertinent information for various purposes, including flood mapping and hydraulic structure design.

Line 742: A last sentence could be: "Maintaining funding and constantly improving

hydrological estimation and measurements approaches is needed to maintain an adequate level of knowledge and to update the CRID in the future."

Lines 1042-1044: I do not see this paper referred to in the paper and it should removed from the reference.

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